PARK UNIT SHELVES DEVA

BASELINE FLOODPLAIN ANALYSIS

DEATH VALLEY

FLOOD STUDIES

NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
FORT COLLINS, COLORADO
RESOURCE ROOM PROPERTY

NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
FORT COLLINS, COLORADO
RESOURCE ROOM PROPERTY

BASELINE FLOODPLAIN ANALYSIS

Death Valley National Monument

California and Nevada

Flood Mitigation Studies
Package 271

REPORT ON AREAS:

COW CREEK:

FC-1	Park Village
FC-2A	NPS Maintenance
FC-2B	School Wash
FC-2C	Cow Creek Drainage

FURNACE CREEK:

FC-3	NPS Headquarters and Ranch
FC-5	Furnace Creek Inn, Water Supply, & Indian Village
FC-6	Furnace Creek to Zabriskie Point

STOVEPIPE WELLS

SP-1	Mosaic Canyon
SP-2	Stovepipe Wells Development

EMIGRANT

Emigrant Canyon
Emigrant Ranger Station

MESQUITE CAMPGROUND

SCOTTY'S CASTLE

SC-1	Tie Canyon
SC-2	Castle Area
SC-2	Water Supply
SC-3	Grapevine Canyon

Prepared by:

Dan Overzet, Civil Engineer, DSC
R.F. Brunson, Civil Engineer, DSC
Ron Greslin, Student Engineer, DSC

Digitized by the Internet Archive
in 2012 with funding from
LYRASIS Members and Sloan Foundation

http://archive.org/details/baselinefloodpla00over

GENERAL BACKGROUND

PURPOSE

The purpose of this study is to determine (1) the precipitation and runoff for selected areas by methods based on gauged rainfall of record and basin characteristics; (2) the extent of flooding at selected critical sections; and (3) the locations which require some method of flood mitigation.

STUDY AREAS

This report includes studies for six separate drainage areas. Each area is comprised of one or more combined or separate drainage basins. The study areas are Cow Creek, Furnace Creek, Stovepipe Wells, Emigrant, Mesquite Campground, and Scotty's Castle.

PREVIOUS REPORTS

An introduction to the general flood problems of Death Valley, geographic setting, general discussion of precipitation, and the equations used to determine floodflows for different probabilities of frequency are included in a study titled, Potential Hazards From Floodflows and Debris Movement in the Furnace Creek Area, by John R. Crippen, USGS. The report identifies the potential problems and gives the extent of flooding for 25-year, 50-year, and 100-year floods for the Furnace Creek fan and the Park Village Area of Nevares Creek.

Potential Hazards From Floodflows in Grapevine Canyon, by James C. Bowers, USGS, gives a description of the geographic setting, precipitation, flood hydrology, flood discharges, and flood extents within Grapevine Canyon. A map indicating the flooding at Scotty's Castle is included.

Death Valley Flood Studies, BASELINE FLOODPLAIN ANALYSIS, which was done by Denver Service Center, in March, 1984, was a report similar to this report but only studied three areas: Emigrant, Cow Creek, and Stovepipe Wells. Additional topographic surveys have been obtained and the previous DSC report has been updated and is incorporated into this report.

METHODOLOGY

Precipitation for the 100-year storm was determined using the procedures and isopluvials in NOAA ATLAS 2, Volume XI, prepared by the National Oceanic and Atmospheric Administration. Precipitation for the probable maximum thunderstorm was determined using the procedures and isohyets as prescribed in DESIGN OF SMALL DAMS, Second Edition, Bureau of Reclamation.

Runoff was determined by the procedures described in DESIGN OF SMALL DAMS, and USGS Topographic Maps.

Flood extents at critical sections were determined using Manning's Formula with an "n" value of 0.045 and cross-sections of the drainages.

RESULTS AND RECOMMENDATIONS

The results and recommendations for each study area are given in the respective sections. The report is sectionalized to facilitate using each study as a separate report, if desired.

COW CREEK

BASELINE FLOODPLAIN ANALYSIS

Death Valley National Monument
California and Nevada

Flood Mitigation Studies
Package 271

REPORT ON AREAS:

→ COW CREEK:

FC-1	Park Village
FC-2A	NPS Maintenance
FC-2B	School Wash
FC-2C	Cow Creek Drainage

FURNACE CREEK:

FC-3	NPS Headquarters and Ranch
FC-5	Furnace Creek Inn, Water Supply, & Indian Village
FC-6	Furnace Creek to Zabriskie Point

STOVEPIPE WELLS

SP-1	Mosaic Canyon
SP-2	Stovepipe Wells Development

EMIGRANT

Emigrant Canyon
Emigrant Ranger Station

MESQUITE CAMPGROUND

SCOTTY'S CASTLE

SC-1	Tie Canyon
SC-2	Castle Area
SC-2	Water Supply
SC-3	Grapevine Canyon

Prepared by:
Dan Overzet, Civil Engineer, DSC
R.F. Brunson, Civil Engineer, DSC
Ron Greslin, Student Engineer, DSC

COW CREEK AREAS

GENERAL BACKGROUND

An introduction to the general flood problems of Death Valley, geographic setting, general discussion of precipitation, and the equations used to determine floodflows for different probabilities of frequency are included in a study titled Potential Hazards from Floodflows and Debris Movement in the Furnace Creek Area, by John R. Crippen, USGS. The report identifies the potential problems and gives the extent of flooding for 25-year, 50-year, and 100-year floods for the Furnace Creek fan and the Park Village Area of Nevares Creek.

The Task Directive for Flood Mitigation Studies, Packages 271 and 301, which was approved by Regional Director Howard Chapman on December 10, 1983, designated various areas of concern within the greater Furnace Creek Development as FC-1 through FC-7. FC-1 is the Park Village (Nevares Creek) and FC-2 is the Park Service Development and Maintenance Area (Cow Creek).

PURPOSE

The purpose of this study is to determine (1) the precipitation and runoff for FC-1 and FC-2 by methods based on gauged rainfall of record and basin characteristics; (2) the extent of flooding at selected critical sections; and (3) the locations which require some method of flood mitigation.

STUDY AREAS

The areas of concern for this report include four separate drainage basins shown on the USGS map on page 3 as FC-1, Park Village; FC-2A, NPS maintenance area; FC-2B, school area; and FC-2C, Cow Creek proper. Table 1 on page 5 gives the drainage area characteristics for FC-1, FC-2A, and FC-2B. Aerial reconnaissance and aerial photographs revealed that runoff from FC-2C, the Cow Creek drainage area, will not affect any development.

METHODOLOGY

Precipitation for the 100-year storm was determined using the procedures and isopluvials in NOAA ATLAS 2, Volume XI, prepared by the National Oceanic and Atmospheric Administration. Precipitation for the probable maximum thunderstorm was determined using the procedures and isohyets as prescribed in DESIGN OF SMALL DAMS, Second Edition, Bureau of Reclamation.

Runoff was determined by the procedures described in DESIGN OF SMALL DAMS, and USGS Topographic Map, Chloride Cliff, California.

Precipitation and runoff for the areas are summarized in Table 2 on page 6.

Flood extents at critical sections were determined using Manning's Formula with an "n" value of 0.045 and cross-sections of the drainages taken on-site. The following plans showing the locations of sections were taken from half-size prints of Drawing Number 143-41019A.

RESULTS

FC-1. The drainage adjacent to the Park Village housing will not threaten the housing area; however, the access road will periodically be washed out. See pages 7 and 8.

FC-2A. Runoff near the maintenance area will not affect any development in the area including the recent construction adjacent to the drainage arroyo. See pages 9 and 10.

FC-2B. Runoff from the FC-2B drainage area is barely contained in the existing ditches for the 100-year flood. Any amounts in excess of 290 cubic feet per second will overflow the channel. The school is in a hazardous location with the existing drainage provisions. See pages 11, 12, 13, and 14.

FC-2C. The drainage area for Cow Creek proper will not pose a threat to any developed area. Highway 190 could wash out, however, in a large storm.

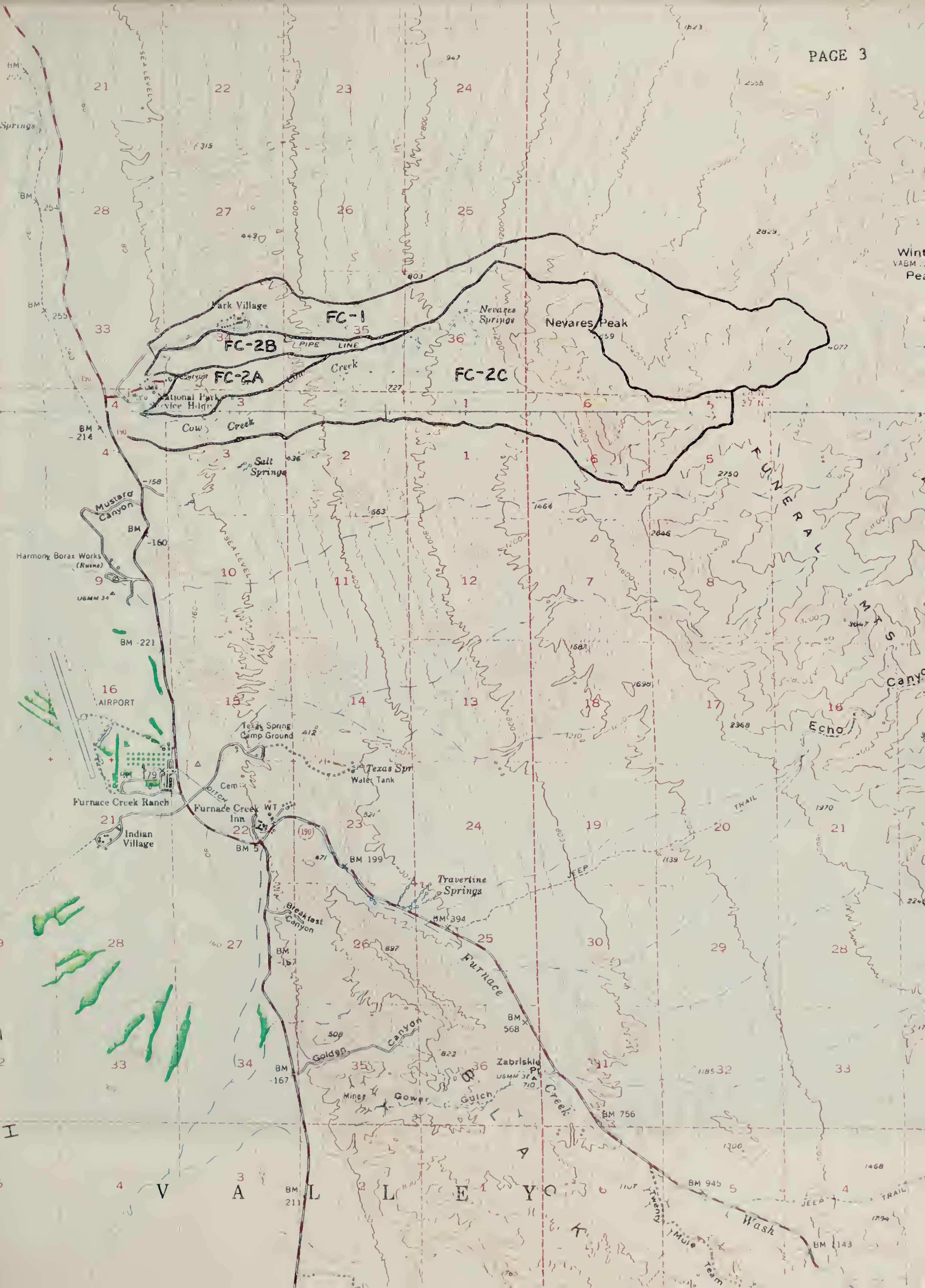
RECOMMENDATIONS FOR FURTHER STUDY AND FLOOD MITIGATION

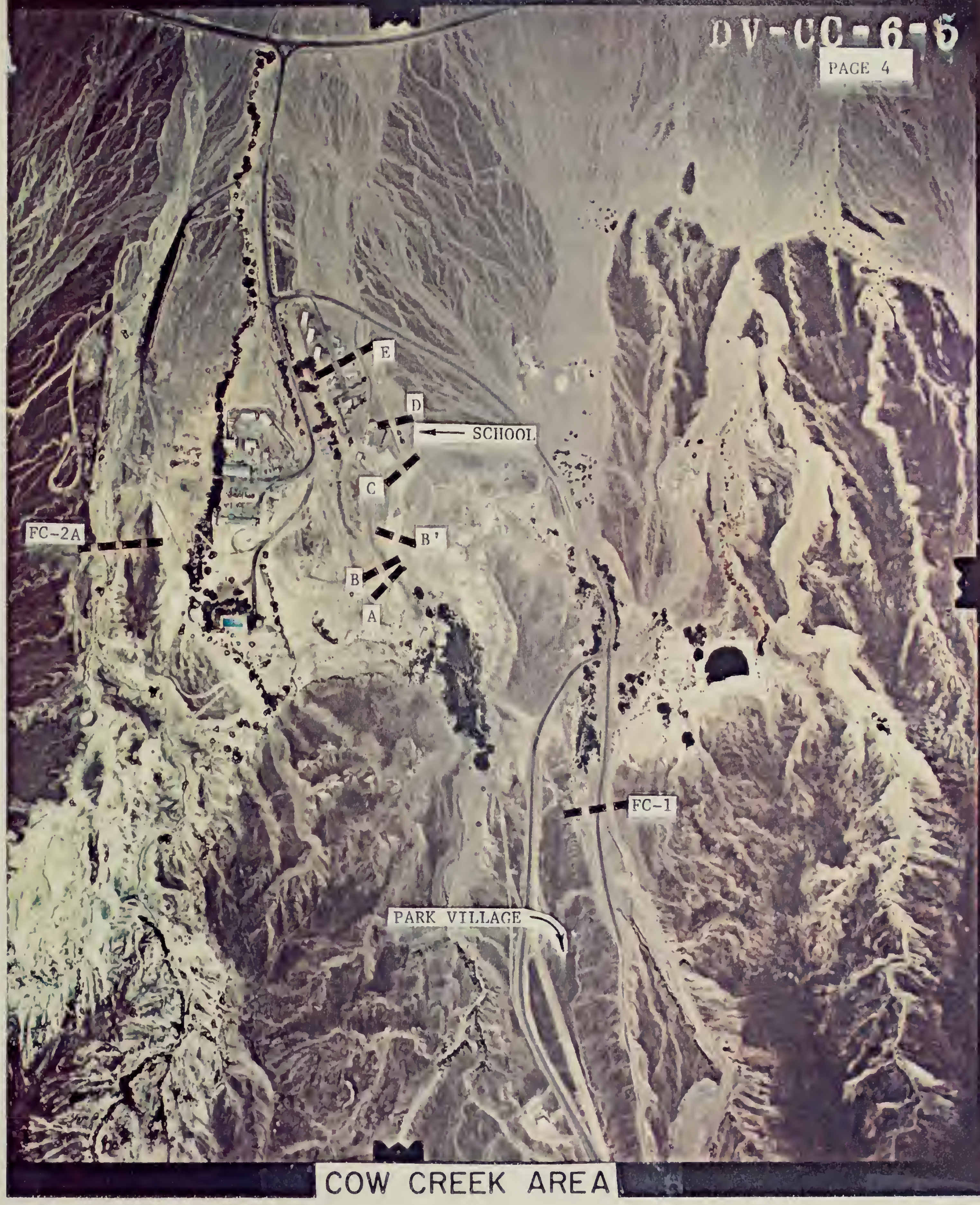
FC-1: A drainage ditch lined with riprap or cemented rubble could be designed to contain the 50-year-floodflow. The highway could be dipped and the shoulders paved to withstand higher flows. A dip in the highway just above the intersection with Skyline Drive would also help to prevent floodwaters from FC-1 crossing over into FC-2B, the School Wash.

FC-2A: No action necessary.

FC-2B: The existing drainage channel should be lined to prevent washouts and enlarged to contain a flow in excess of the 100-year flow with freeboard allowed. The fairly small drainage area would not generate a life-threatening flood; however, damage to the school and trailer court could occur. The lined channel should continue through the trailer court.

FC-2C: No action recommended; however, a dip in Highway 190 could be installed to prevent washouts for the 50-year flood.


FC-1
FC-2B
FC-2A
FC-2C
Park Village
PIPE LINE
Nevares Springs
Nevares Peak
National Park Service Hdqrs
Cow Creek
Salt Springs
Mustard Canyon
Harmony Borax Works (Ruins)
AIRPORT
Texas Spring Camp Ground
Texas Spr
Water Tank
Furnace Creek Ranch
Furnace Creek Inn
Indian Village
Travertine Springs
Breakfast Canyon
Furnace Creek
Golden Canyon
Gower Gulch
Mines
Zabriskie Pt
Twenty Mule Team
Wash
Echo Canyon
FUNERAL MTS
BLACK
VALLEY
SEA LEVEL
TRAIL
JEEP
DITCH
Cem
Springs
Wint
Pea
190
BM 199
BM 394
BM 568
BM 756
BM 945
BM 143
BM -214
BM -221
BM -160
BM -167
BM 211
BM 5
USMM 34
USMM 37
4077
2829
2559
2750
2646
2368
3047
1464
1587
1698
1210
663
727
603
947
1623
2556
897
823
508
471
521
412
315
36
1139
1185
1970
1468
1794
1300



COW CREEK AREA

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 5
Area Cow Creek Areas (FC-1 FC-2A,B)			**of**
Project	**By** D. O.	**Checked**	**Pkg.**
Feature	**Date** 2/14/84	**Date**	**Account**

TABLE 1 - DRAINAGE AREA CHARACTERISTICS

AREA NAME	AREA (MI.²)	LENGTH (MILES)	TIME OF CONC. (MIN.)	ELEV. MAX. (FEET)	ELEV. MIN. (FEET)	AVE. CHANNEL SLOPE.
FC-1 Park Village	2.55	6.12	51.2	4077	-40	0.1274
FC-2B School Wash	0.40	2.25	29.7	720	-120	0.0707
FC-2A NPS Mainten.	0.39	1.85	27.0	480	-120	0.0614

TIMES OF CONCENTRATION

$$T_c = \left(\frac{11.9\ L^3}{\Delta E}\right)^{0.385}$$

L = LENGTH IN MILES

T_c = TIME OF CONCENTRATION (HRS)

ΔE = DIFFERENCE IN ELEVATION (FT.)

FC-1 PARK VILLAGE $= \left[\frac{11.9(6.12)^3}{4077-(-40)}\right]^{0.385} = 0.853$ HRS. = 51.2 MIN.

FC-2B SCHOOL WASH $= \left[\frac{11.9\ (2.25)^3}{720-(-120)}\right]^{0.385} = 0.495$ HRS. = 29.7 MIN.

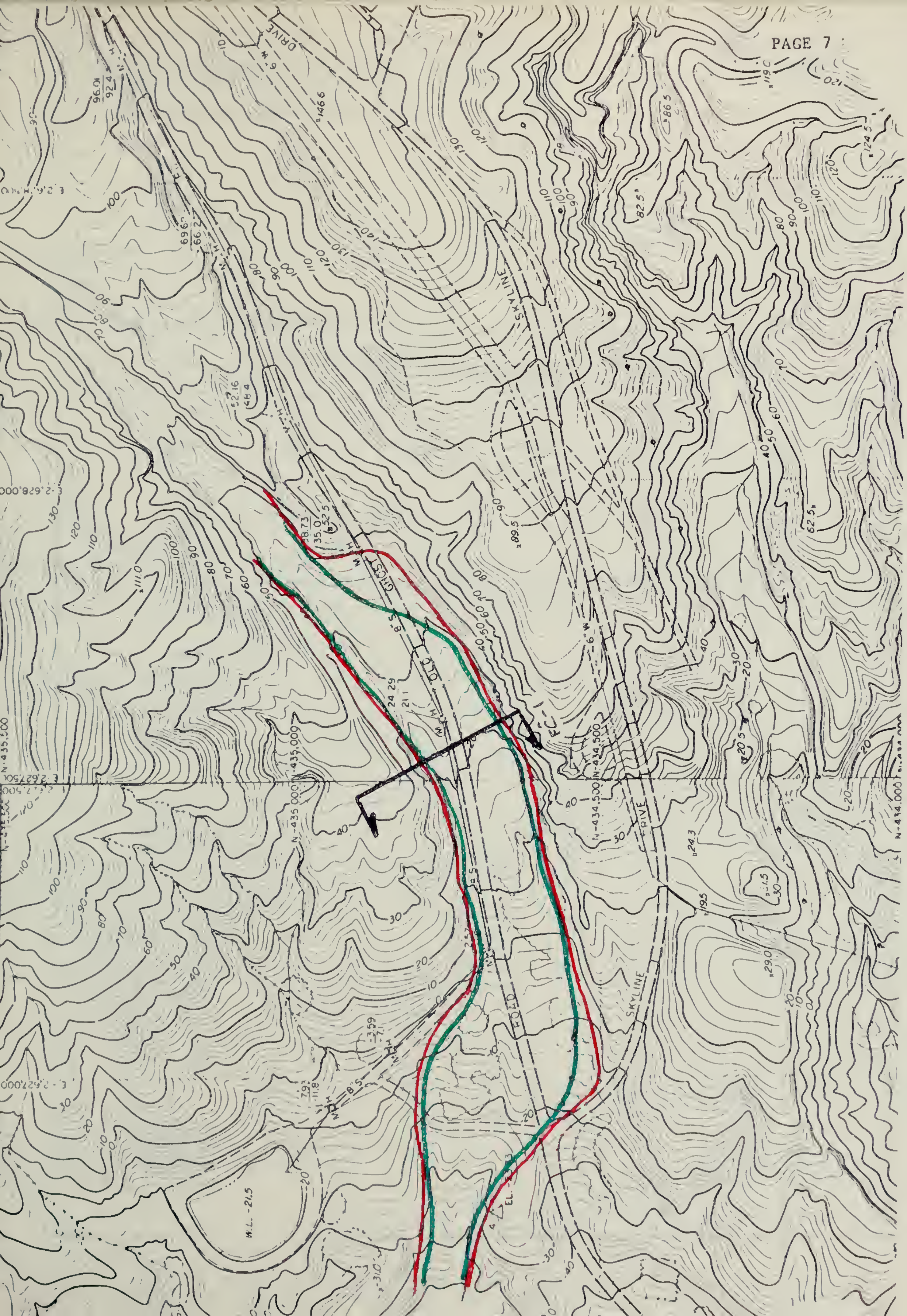
FC-2A NPS MAINTENANCE $= \left[\frac{11.9\ (1.85)^3}{480-(-120)}\right]^{0.385} = 0.450$ HRS. = 27.0 MIN.

FORM D S C - 44

Park DEATH VALLEY N.M.	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 6
Area COW CREEK AREAS - FC-1,2A,2B			of
Project	By D.O.	Checked RFB	Pkg.
Feature	Date	Date	Account

TABLE 2 PRECIPITATION & RUNOFF

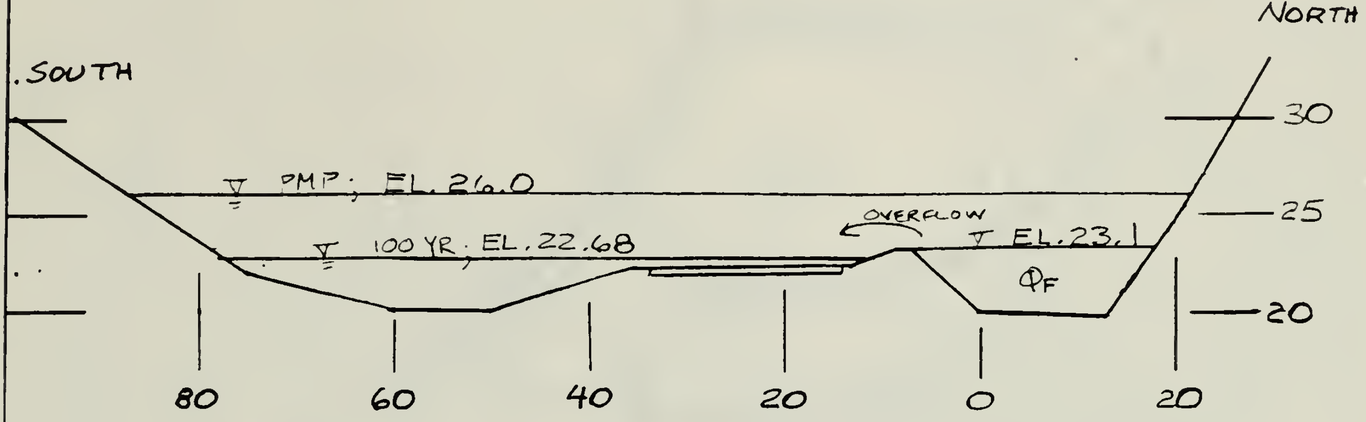
AREA NAME	FC-1 PARK VILLAGE	FC-2A MAINTENANCE	FC-2B SCHOOL AREA
100 YR. PRECIPITATION			
5 MINUTE	0.33 IN.	0.35 IN.	0.35 IN.
10 MINUTE	0.51 IN.	0.54 IN.	0.54 IN.
15 MINUTE	0.64 IN.	0.69 IN.	0.69 IN.
30 MINUTE	0.89 IN.	0.96 IN.	0.96 IN.
1 HOUR	1.13 IN.	1.21 IN.	1.21 IN.
2 HOUR	1.25 IN.	1.26 IN.	1.26 IN.
3 HOUR	1.36 IN.	1.31 IN	1.31 IN.
PROPABLE MAXIMUM			
15 MINUTE	2.88 IN.	2.88 IN	2.88 IN
30 MINUTE	4.26 IN	4.26 IN	4.26 IN
45 MINUTE	5.28 IN	5.28 IN	5.28 IN
1 HOUR	6.00 IN	6.00 IN	6.00 IN
2 HOUR	7.56 IN	7.56 IN	7.56 IN.
3 HOUR	8.04 IN.	8.04 IN	8.04 IN.
AREAS	2.55 MI.^{2}	0.39 MI.^{2}	0.40 MI.^{2}
100 YR. RUNOFF	1225 FT^3/SEC.	300 FT^3/SEC	290. FT^3/SEC
PROB. MAX. RUNOFF	7170 FT^3/SEC	1500 FT^3/SEC.	1480 FT^3/SEC.



PARK VILLAGE ACCESS ROAD - FC-1

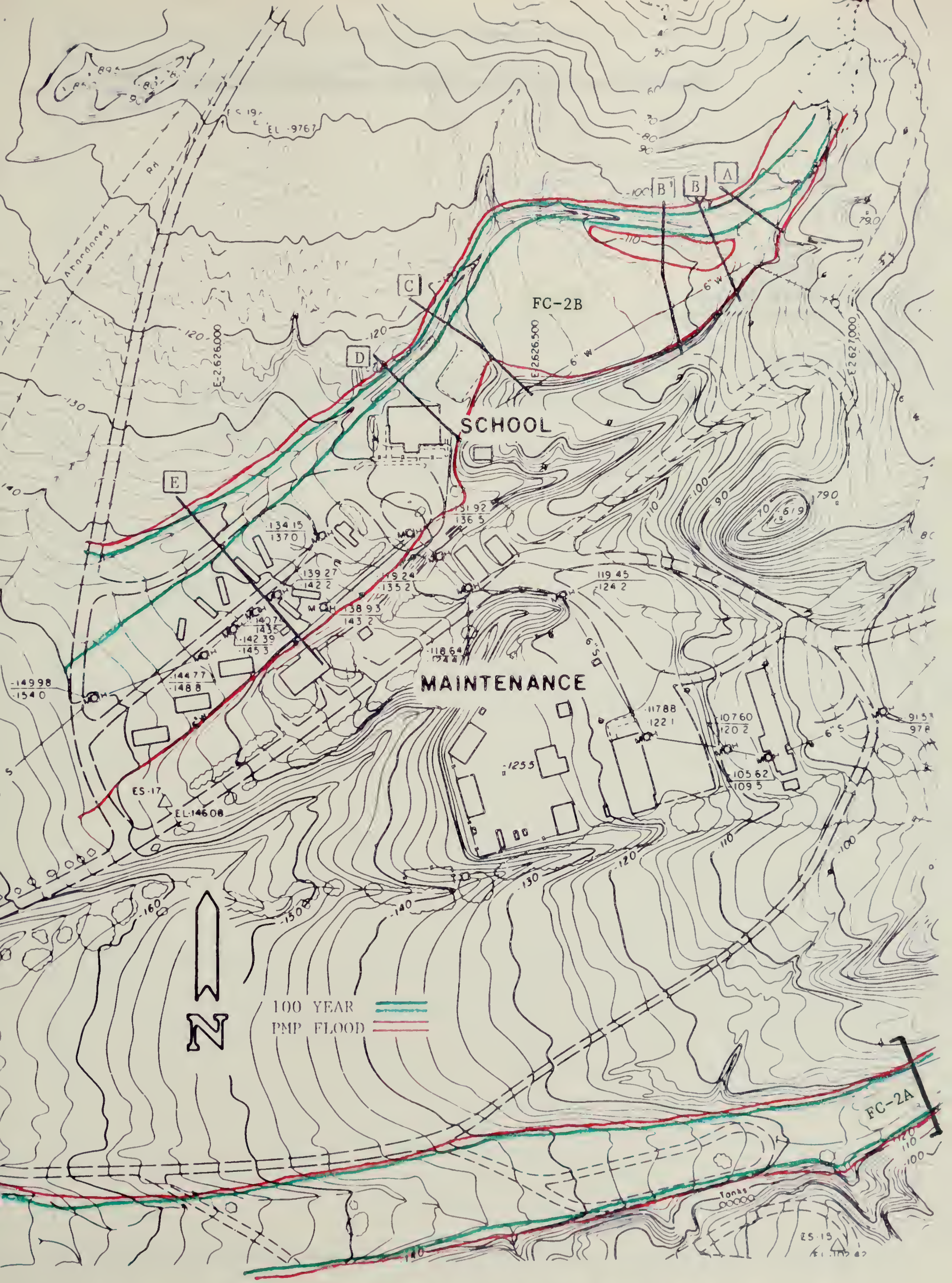
PARK VILLAGE ROAD - FC-1

CRITICAL SECTION



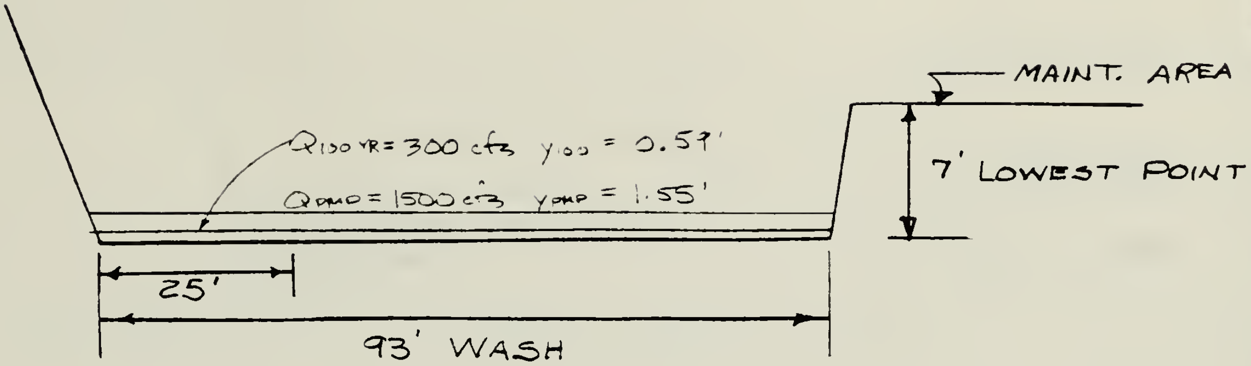
Q_{100} = 1225 cfs
Q_{PMP} = 7170 cfs
S = 0.03 n = 0.045
Q_F = NORTH DITCH FULL FLOW = 595 FT.^{3}/SEC.
V_F = 10 F.P.S

V_{PMP} = 15 FPS



SCHOOL & MAINTENANCE AREAS FC-2a, 2b

COW CREEK- MAINT. AREA WASH (FC-2A)


MAINT. AREA
7' LOWEST POINT
$Q_{100\,YR}$ = 300 cfs y_{100} = 0.59'
Q_{PMP} = 1500 cfs y_{PMP} = 1.55'
25'
93' WASH

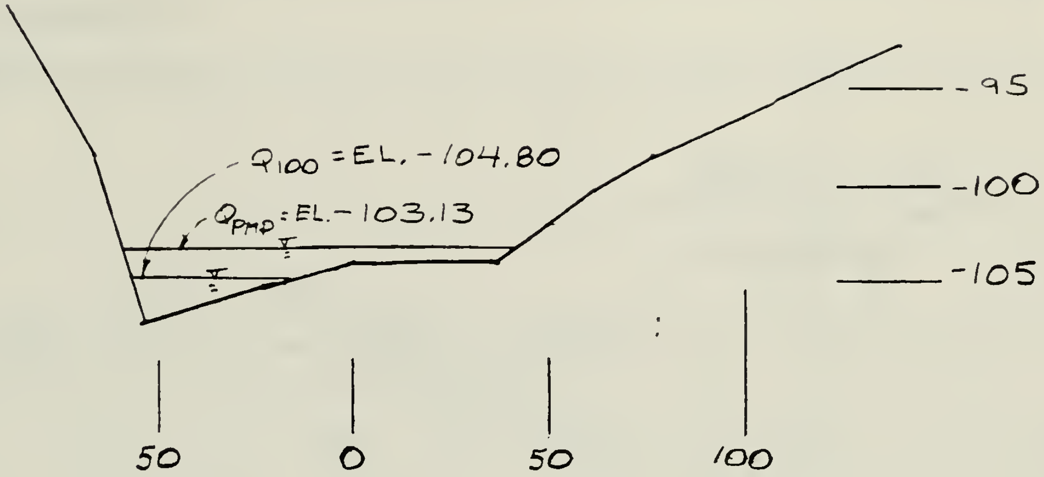
Q = FLOW

n = 0.045

S = 0.056

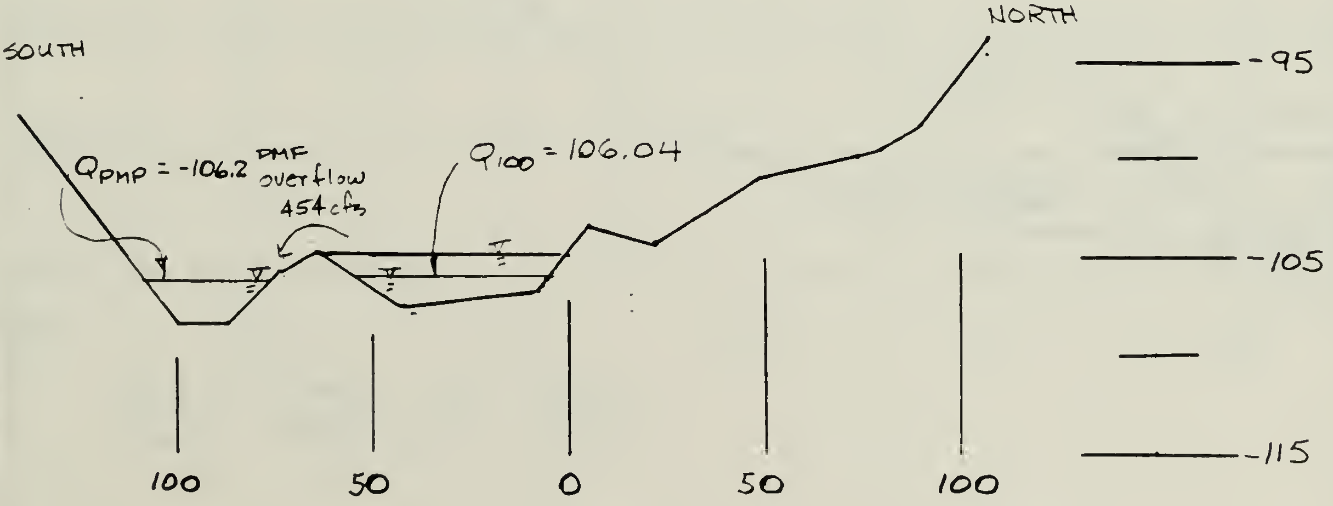
SCHOOL DRAINAGE (FC-2B)

SECTION A



Q_{100} = 290 cfs
Q PMF = 1480 cfs
S = .036 n = 0.045
V_{PMP} = 8.7 fps
V_{100} = 6.3 fps

SECTION B



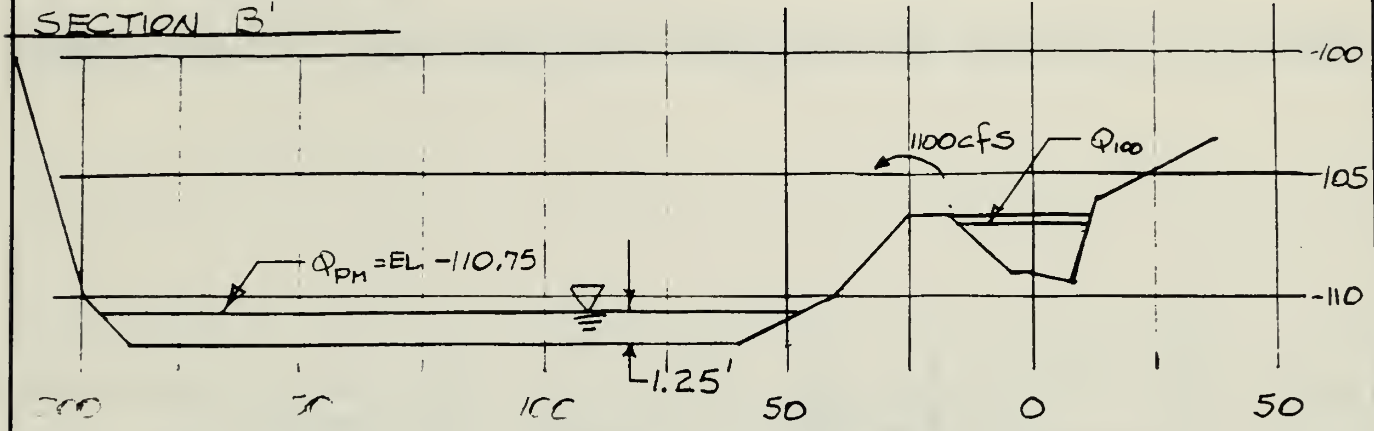
Q_{100} = 290 cfs
Q_F = .020
V_{100} = 6.1 FT/SEC.
Q_{PMF} = 1480 cfs
S = 0.036 n = 0.045

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 12
Area			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

FC-2B (CON'T)

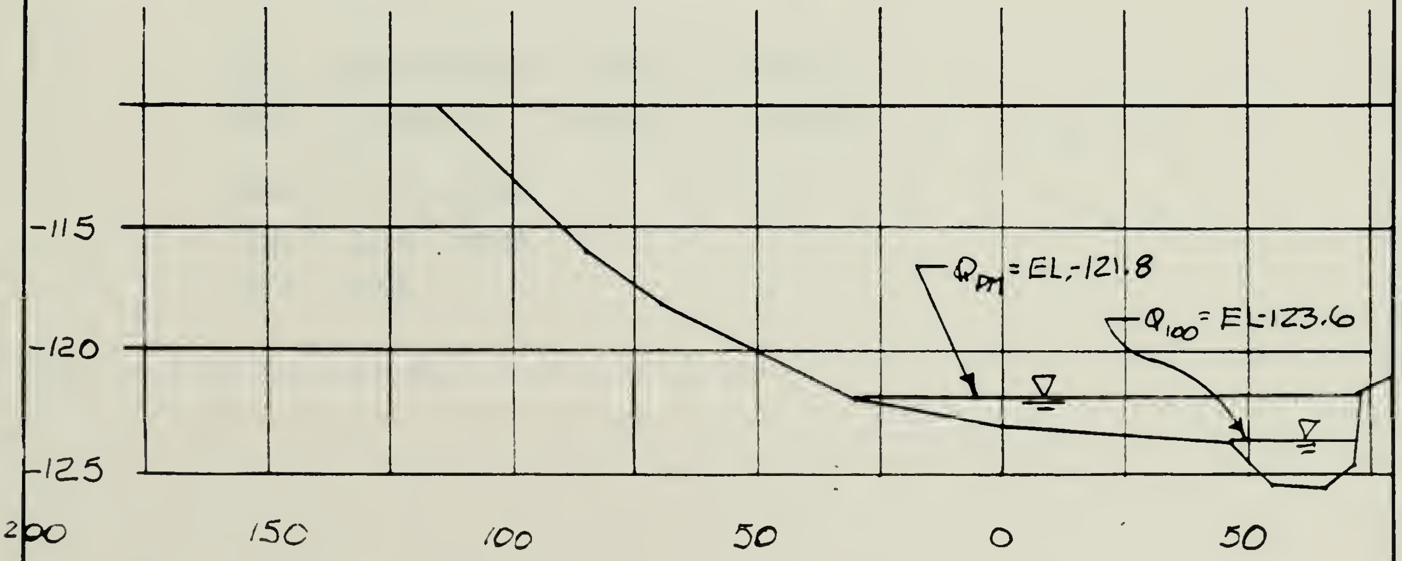
SECTION B'



Q_{100} = 290cfs
Q_{PM} = 1480cfs
S = 0.027 ; n = 0.045

Q_F = 378 cfs
Q_{100} = EL. -107
Q_{PM} = EL. -110.75

SECTION C - 18' UPSTREAM OF SCHOOL COURT



Q_{100} = 290cfs = EL.-123.6
Q_{PM} = 1480cfs = EL.-121.8

•U.S. GPO: 1984-778-378

FORM D S C - 44

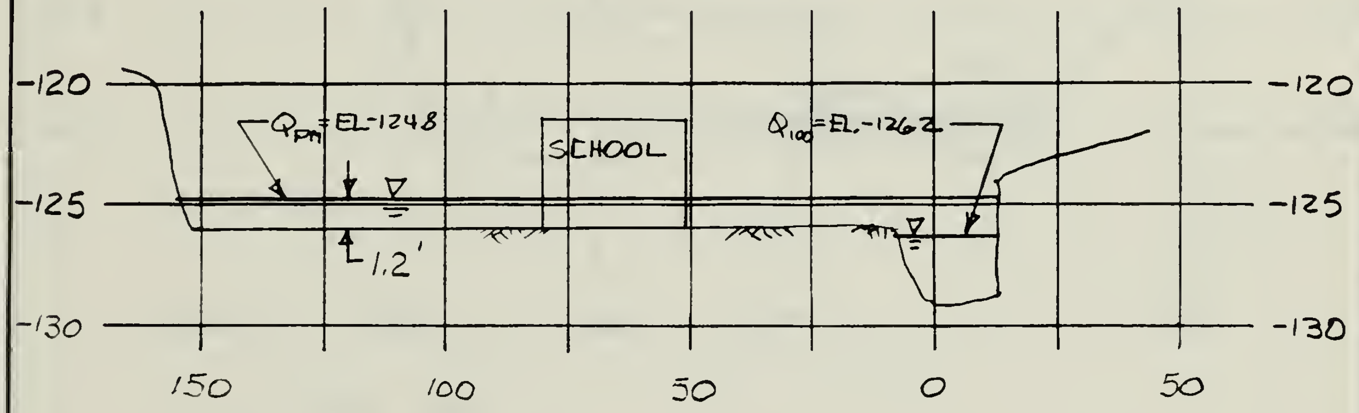
Park
Area

NATIONAL PARK SERVICE
DENVER SERVICE CENTER

Sheet 13
of
Project
By
Checked
Pkg.
Feature
Date
Date
Account

FC-2B (CON'T)

SECTION D: 50' UPSTREAM FROM END OF SCHOOL YARD FENCE



Q_{100} = 290 cfs = ELEV. − 126.2
Q_{PM} = 1480 cfs = ELEV. − 124.8

V_{100} = 7.0 fps
V_{PM} = 6.0 fps
S = .02

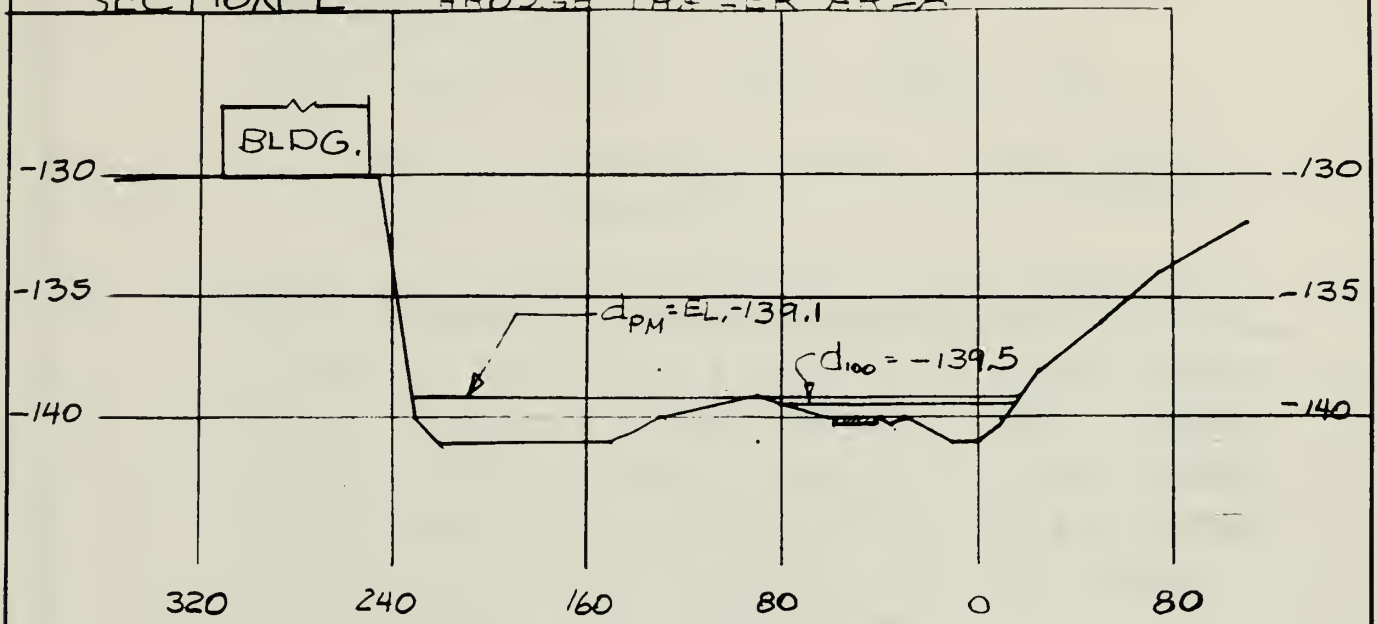
*U.S. GPO: 1984-778-378

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 14
Area			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

FC-2B (CON'T)

SECTION E - THROUGH TRAILER AREA



Q_{100} = 290 CFS

Q_{PM} = 1480 CFS

S = .022

V = 4.84

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 15
Area PARK VILLAGE - (FC-1)			of
Project	By D.D	Checked	Pkg.
Feature	Date 2'84	Date	Account

II PRECIPITATION

A FIND PRECIPITATION FOR 100 YR. FREQUENCY

AREA FC-1

6 HR., 100 YR. POINT = 1.6 INCHES = X_3

24 HR., 100 YR. POINT = 2.5 INCHES = X_4

Y_{100} = 100 YR., 1 HR. RAIN = $0.322 + 0.789 \left[\frac{X_3^2}{X_4} \right]$

= 1.13 INCHES/HR.

FIND AMOUNTS FOR VARIOUS DURATIONS

100 YR., 5 MIN. = 0.29 (1.13) = 0.33 INCHES
100 YR., 10 MIN. = 0.45 (1.13) = 0.51 INCHES
100 YR., 15 MIN. = 0.57 (1.13) = 0.64 INCHES
100 YR., 30 MIN. = 0.79 (1.13) = 0.89 INCHES
100 YR., 1 HR. = 1 (1.13) = 1.13 INCHES
100 YR., 2 HR. = 1.25 INCHES
100 YR., 3 HR. = 1.36 INCHES

Information from NOAA Atlas 2, Volume XI —
Death Valley is in Region 6 for 100 YR. - 1 HR. values.
It is the southeastern desert Region of California.
No adjustment for area size required.

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 16
Area MAINTENANCE AND SCHOOL AREAS			of
Project FLOOD STUDIES	By 2 3+	Checked	Pkg.
Feature	Date D. C[illegible]	Date	Account

II PRECIPITATION

A FIND PRECIPITATION FOR 100 YR. FREQUENCY

AREAS FC-2A AND FC-2B

6 HR., 100 YR. POINT = 1.5 INCHES = X_3

24 HR., 100 YR. POINT = 2.0 INCHES = X_4

Y_{100} = 100 YR., 1 HR. RAIN = $0.322 - 0.789 \left[X_3 \left(X_3/X_4\right)\right]$

= 1.21 INCHES / HR.

FIND AMOUNTS FOR VARIOUS DURATIONS

100 YR., 5 MIN. = 0.29 (1.21) = 0.35 INCHES
100 YR., 10 MIN. = 0.45 (1.21) = 0.54 INCHES
100 YR., 15 MIN. = 0.57 (1.21) = 0.69 INCHES
100 YR., 30 MIN. = 0.79 (1.21) = 0.96 INCHES
100 YR., 1 HR. = 1 (1.21) = 1.21 INCHES
100 YR., 2 HR. = 1.26 INCHES
100 YR., 3 HR. = 1.31 INCHES

Information from NOAA Atlas 2, Volume XI –

Death Valley is in Region 6 for 100 yr. - 1 HR. values. Its the southeastern desert region of California.

No adjustment for area size required.

FORM D S C - 44

Park Death Valley N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 17
Area Cow Creek Areas			**of**
Project	**By** D.O.	**Checked**	**Pkg.**
Feature	**Date** 2/4/84	**Date**	**Account**

II PRECIPITATION (CONT.)

3 FIND PROBABLE MAXIMUM RAINFALL

AREAS: FC-1, FC-2A & 3

1 HOUR POINT RAINFALL = 6 INCHES / HR.

Death Valley lies in Zone II —
No adjustment for area required.

RAINFALL FOR OTHER DURATIONS

15 MIN. = 0.48 (6) = 2.88 INCHES
30 MIN. = 0.71 (6) = 4.26 INCHES
45 MIN. = 0.88 (6) = 5.28 INCHES
1 HR. = 1 (6) = 6 INCHES
2 HR. = 1.26 (6) = 7.56 INCHES
3 HR. = 1.34 (6) = 8.04 INCHES

Information for Probable Maximum Rainfall from:
"Design of Small Dams" - by U.S. Dept. of Interior.
Bureau of Reclamation. - 1974

FORM D S C - 44

Park Death Valley N.M	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 18
Area Cow Creek : FC-1			of
Project	By D.J.	Checked	Pkg.
Feature	Date 2-84	Date	Account

III RUNOFF

A. 100 YR. FLOOD

FC-1 - PARK VILLAGE

Rainfall Retention Assumptions : Mountains : 0.1"
Bajada : 0.15"

Total Retained : 40 % Mounts. × 0.1" + 60% × .15" = 0.13"

$T_c = 0.853$ HRS. A = 2.55 mi².

DURATION = 5 MIN.

$T_p = .25/2 + .6(0.853) = 0.6368$

$$Q_p = \frac{484(2.55)(0.64-.13)}{0.6368} = 988 \text{ cfs}$$

DURATION = 30 MIN.

$T_p = .5/2 + .6(0.853) = 0.7681$

$$Q_p = \frac{434(2.55)(0.89-.13)}{0.7681} = 1221 \text{ cfs}$$

DURATION = 1 HR.

$T_p = 1/2 + .6(0.853) = 1.0118$

$$Q_p = \frac{434(2.55)(1.13-.13)}{1.0118} = 1220 \text{ cfs}$$

DURATION = 2 HR.

$T_p = 2/2 + .6(0.853) = 1.5118$

$$Q_p = \frac{434(2.55)(1.25-.13)}{1.5118} = 914 \text{ cfs}$$

TRY RATIONAL METHOD - 2 HR. STORM

$$Q_p = CIA = 1.00\left(\frac{1.25}{2\text{ HR}}\right)(640)(2.55)$$

$= 1020$ cfs

TRY RATIONAL METHOD - 1 HR. STORM

(assuming no retention on soil after 1 HR.)

$$Q_p = CIA = 1.00\left(\frac{1.13}{\text{HR.}}\right)640(2.55)$$

$= 1344$ cfs.

USE 1225 cfs

FORM D S C - 44

Park Death Valley N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 19
Area Cow Creek (FC-2A)			**of**
Project	**By** D.O.	**Checked**	**Pkg.**
Feature	**Date** 2/17/84	**Date**	**Account**

III RUNOFF

A. 100 YR FLOOD

$T_p = D/2 + 0.6\,T_c$

$Q_p = \dfrac{484\,(A)(Q_t)}{T_p}$

D = Duration (Hrs.)
T_c = Time of Concentration (HRS.)
A = Area (Mi.^{2})
Q_t = Total Rainfall for Specified Duration
Q_p = Peak flow.

FC - 2A — MAINTENANCE AREA

Rainfall Retention Assumptions : Mountains : 0.1"
Bajada : 0.15"

Total Retained = .15"

T_c = 0.45 HRS. A = 0.39 mi^2

DURATION = 15 MIN.

$T_p = .25/2 + 0.6(0.45) = 0.395$

$Q_p = \dfrac{484(0.39)(0.69-.15)}{0.395} = 258$ cfs

DURATION = 30 MIN.

$T_p = 0.5/2 + 0.6(0.45) = 0.52$

$Q_p = \dfrac{484(0.39)(0.96-.15)}{0.52} = 294$ cfs

DURATION = 1 HR.

$T_p = 1/2 + 0.6(0.45) = 0.77$

$Q_p = \dfrac{484(0.39)(1.21-0.15)}{0.77} = 259$ cfs.

TRY RATIONAL METHOD – 30 MIN. STORM (assume no retention by soil after 30 MIN.)

$Q_p = CIA = 1.00\left(\dfrac{0.96}{1/2\text{ HR.}}\right)640(0.39)$

$= 479$ cfs.

TRY RATIONAL METHOD – 1 HR. STORM (assume no retention by soil after 1 HR.)

$Q_p = CIA = 1.00\left(\dfrac{1.21}{\text{HR.}}\right)640(0.39)$

$= 302$ cfs

USE 300 cfs

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 20
Area COW CREEK - FC-23			of
Project	By D.O.	Checked	Pkg.
Feature	Date 2/17/84	Date	Account

III RUNOFF

A. 100 YR. FLOOD

FC-2B - SCHOOL WASH:

Rainfall Retention Assumptions: Mountains : 0.1"
Bahada : 0.15"

Total Retained = .15"

T_c = 0.495 HRS.   A = 0.40 mi²

DURATION = 15 MIN.

$$T_p = .25/2 + 0.6(0.495) = 0.422$$

$$Q_p = \frac{484(0.4)(0.69-.15)}{0.422} = 248 \text{ cfs}$$

DURATION = 30 MIN.

$$T_p = .5/2 + 0.6(0.495) = 0.547$$

$$Q_p = \frac{484(0.4)(0.96-.15)}{0.547} = 287 \text{ cfs}$$

DURATION = 1 HR.

$$T_p = 1/2 + 0.6(0.495) = 0.797$$

$$Q_p = \frac{484(0.4)(1.21-0.15)}{0.797} = 257 \text{ cfs}$$

TRY RATIONAL METHOD - 30 MIN. STORM (assume no retention by soil after 30 MIN.)

$$Q_p = CIA = 1.00\left(\frac{0.96}{\tfrac{1}{2}\text{HR.}}\right)640(0.40)$$

$$= 492 \text{ cfs}$$

TRY RATIONAL METHOD - 1 HR. STORM (assume no retention by soil after 1 HR.)

$$Q_p = CIA = 1.00\left(\frac{1.21}{\text{HR.}}\right)640(0.40)$$

$$= 310 \text{ cfs}$$

USE 290 cfs

FORM D S C - 44

Park Death Valley N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 21
Area Cow Creek FC-1			**of**
Project	**By** D.D.	**Checked**	**Pkg.**
Feature	**Date** 2/17/84	**Date**	**Account**

III RUNOFF

B. PMP FLOOD

FC-1 - PARK VILLAGE:

Rainfall Retention Assumptions: Mountains: 0.1"
Bahada : 0.15"

Total Retained: 40% mtns x 0.1" + 60% x .15" = 0.13"

T_c = 0.353 HRS. A= 2.55 mi.^{2}

DURATION = 30 MIN.

$$T_p = .5/2 + 0.6(0.353) = 0.7618$$

$$Q_p = \frac{484(2.55)(4.26-0.13)}{0.7618} = 6691 \text{ cfs}$$

DURATION = 45 MIN.

$$T_p = .75/2 + 0.6(0.353) = 0.8868$$

$$Q_p = \frac{484(2.55)(5.28-.13)}{0.8868} = 7167 \text{ cfs}$$

DURATION = 1 HR.

$$T_p = 1/2 + 0.6(0.353) = 1.0118$$

$$Q_p = \frac{484(2.55)(6-.13)}{1.0118} = 7160 \text{ cfs}$$

BY RATIONAL METHOD - 1HR. STORM

(assume no retention by soil after 1HR.)

$$Q_p = CIA = 1.00\left(\frac{6}{\text{HR.}}\right)640(2.55)$$

$$= 9792 \text{ cfs}$$

USE 7170 cfs

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** COW CREEK FC-2A	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 22 **of**
Project	**By** D. D. / **Checked**	**Pkg.**
Feature	**Date** [illegible] – 84 / **Date**	**Account**

III RUNOFF

B. PMP FLOOD

$T_p = D/2 + 0.6T_c$

$Q_p = \dfrac{434\,(A)(Q_T)}{T_p}$

D = Duration (HRS.)
T_c = TIME OF CONCENTRATION (HRS.)
A = AREA (MI.^{2})
Q_T = TOTAL RAINFALL FOR SPECIFIED DURATION
Q_p = PEAK FLOW

FC-2A – MAINTENANCE AREA

Rainfall Retention Assumptions : Mountains : 0.1
Bajada : 0.15

Total Retained = 0.15"

T_c = 0.45 HRS. A = 0.39 mi^2

DURATION = 15 MIN.

$T_p = .25/2 + 0.6(0.45) = 0.395$

$Q_p = \dfrac{484\,(0.39)(2.88-.15)}{0.395} = 1305$ cfs

DURATION = 30 MIN.

$T_p = .5/2 + 0.6(0.45) = 0.52$

$Q_p = \dfrac{484\,(0.39)(4.26-.15)}{0.52} = 1492$ cfs

DURATION = 45 MIN.

$T_p = .75/2 + 0.6(0.45) = 0.645$

$Q_p = \dfrac{484\,(0.39)(5.28-.15)}{0.645} = 1501$ cfs

TRY RATIONAL METHOD – 30 MIN. STORM (assume no retention by soil after 30 MIN.)

$Q_p = CIA = 1.00\left(\dfrac{4.26}{\tfrac{1}{2}\text{ HR.}}\right)640(0.39)$

$= 2127$ cfs

TRY RATIONAL METHOD – 45 MIN. STORM (assume no retention by soil after 45 min.)

$Q_p = CIA = 1.00\left(\dfrac{5.28}{.75\text{ HR}}\right)640(0.39)$

$= 1757$ cfs

USE 1500 cfs

FORM D S C - 44

Park Death Valley N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 23
Area Cow Creek : FC-2B			**of**
Project	**By** D.O.	**Checked**	**Pkg.**
Feature	**Date** 2/17/84	**Date**	**Account**

III RUNOFF

B PMP FLOOD

FC-2B - SCHOOL WASH :

Rainfall Retention Assumptions : Mountains : 0.1"
Bahada : 0.15"

Total Retained = .15"

T_c = 0.495 HRS. A = 0.40 mi²

DURATION = 15 MIN.

$$T_p = .25/2 + 0.6(0.495) = 0.422$$

$$Q_p = \frac{484(0.4)(2.88-.15)}{0.422} = 1252 \text{ cfs}$$

DURATION = 30 MIN.

$$T_p = .5/2 + 0.6(0.495) = 0.547$$

$$Q_p = \frac{484(0.4)(4.26-.15)}{0.547} = 1455 \text{ cfs}$$

DURATION = 45 MIN.

$$T_p = .75/2 + 0.6(0.495) = 0.672$$

$$Q_p = \frac{484(0.4)(5.28-.15)}{0.672} = 1478 \text{ cfs}$$

TRY RATIONAL METHOD - 30 MIN. STORM (assume no retention by soil after 30 MIN.)

$$Q_p = CIA = 1.00\left(\frac{4.26}{1/2 \text{ HR.}}\right)640(0.4)$$

$$= 2181 \text{ cfs}$$

TRY RATIONAL METHOD - 45 MIN. STORM (assume no retention by soil after 1HR.)

$$Q_p = CIA = 1.00\left(\frac{5.28}{.75 \text{ HR.}}\right)640(0.4)$$

$$= 1802 \text{ cfs}$$

USE 1430 cfs

FURNACE CREEK

BASELINE FLOODPLAIN ANALYSIS

Death Valley National Monument
California and Nevada

Flood Mitigation Studies
Package 271

REPORT ON AREAS:

COW CREEK:

FC-1	Park Village
FC-2A	NPS Maintenance
FC-2B	School Wash
FC-2C	Cow Creek Drainage

→ FURNACE CREEK:

FC-3	NPS Headquarters and Ranch
FC-5	Furnace Creek Inn, Water Supply, & Indian Village
FC-6	Furnace Creek to Zabriskie Point

STOVEPIPE WELLS

SP-1	Mosaic Canyon
SP-2	Stovepipe Wells Development

EMIGRANT

- Emigrant Canyon
- Emigrant Ranger Station

MESQUITE CAMPGROUND

SCOTTY'S CASTLE

SC-1	Tie Canyon
SC-2	Castle Area
SC-2	Water Supply
SC-3	Grapevine Canyon

Prepared by:
Dan Overzet, Civil Engineer, DSC
R.F. Brunson, Civil Engineer, DSC
Ron Greslin, Student Engineer, DSC

FURNACE CREEK AREAS

GENERAL BACKGROUND

An introduction to the general flood problems of Death Valley, geographic setting, general discussion of precipitation, and the equations used to determine floodflows for different probabilities of frequency are included in a study titled Potential Hazards from Floodflows and Debris Movement in the Furnace Creek Area, by John R. Crippen, USGS. The report identifies the potential problems and gives the extent of flooding for 25-year, 50-year, and 100-year floods for the Furnace Creek fan and the Park Village Area of Nevares Creek.

The Task Directive for Flood Mitigation Studies, Packages 271 and 301, which was approved by Regional Director Howard Chapman on December 10, 1983, designated various areas of concern within the greater Furnace Creek Development as FC-1 through FC-7. FC-1 is the Park Village (Nevares Creek) and FC-2 is the Park Service Development and Maintenance Area (Cow Creek), both of which are examined in the Cow Creek Section of this study.

PURPOSE

The purpose of this study is to determine (1) the precipitation and runoff for areas FC-3, FC-5, and FC-6 by methods based on gauged rainfall of record and basin characteristics; (2) the extent of flooding at selected critical sections; and (3) the locations which require some method of flood mitigation.

STUDY AREAS

The areas of concern for this report include five areas which are FC-3, the Headquarters Wash; FC-5, Furnace Creek Inn; FC-5, Water Supply Area; FC-5, Indian Village; and FC-6, Zabriskie Point Area. The areas are indicated on an overall map on page 8, and on more detailed maps on pages 9 through 12. Table 1 on page 13 gives the drainage area characteristics for FC-3, FC-5, and FC-6.

SPECIAL CONSIDERATIONS

Although this study is to determine the extent of flooding with the existing conditions, the extent of flooding for the Furnace Creek Inn Area was determined for the existing conditions; for FC-5 only by assuming no flow from FC-6; for FC-5 plus the 10-year maximum flow from FC-6; and for FC-5 and all of the flow from FC-6.

The amount of flow from FC-6 depends on how much of the flow is diverted into Gower Gulch at Zabriskie Point.

For the water intake area in Furnace Creek, the sections and flood extent were determined for the flow from FC-5 plus the 10-year maximum flow from FC-6. For comparison, the extent of flows for the existing conditions, for forcing all of FC-6 to enter FC-5, and for preventing any of FC-6 from entering FC-5 are shown on additional sections at Section 5E.

METHODOLOGY

Precipitation for the 100-year storm was determined using the procedures and isopluvials in NOAA ATLAS 2, Volume XI, prepared by the National Oceanic and Atmospheric Administration. Precipitation for the probable maximum thunderstorm was determined using the procedures and isohyets as prescribed in DESIGN OF SMALL DAMS, Second Edition, Bureau of Reclamation.

Runoff was determined by the procedures described in DESIGN OF SMALL DAMS, using USGS Topographic Maps; Furnace Creek, Calif.; Big Dune, Nev.-Calif.; Ryan, Calif.-Nev.; and Funeral Peak, Calif.

Precipitation and runoff for the areas are summarized in Table 2 on page 14.

Flood extents at critical sections were determined using Manning's Formula with an "n" value of 0.045 and cross-sections of the drainages taken on-site or from sections taken from half-size prints of Drawing Number 143-41016A. These same plans were used to show the locations of the sections for the Furnace Creek Fan Area. The locations of sections for Zabriski Point are shown on a one-half size copy of Drawing Number 143-41092.

FC-3 HEADQUARTERS WASH RESULTS AND RECOMMENDATIONS

Results: As indicated on the aerial photograph on page 15 and the topography map on page 16, the 100-year flood and the probable maximum flood will flow directly to the Visitor Center (Headquaters Building). The flow may spread over a wide area and only be one to two feet deep; however, it is also likely that the flow may channelize and scour a channel only a few hundred feet wide and several feet deep. The Headquarters Building lies at the low point in the drainage and is in the most vulnerable location. The 100-year flood will be contained mostly on the south side of the wash as far down as the Texas Spring Campground access road. The flow will then spread out until it is contained again at the depression formed at the junction between the Headquarters Wash Fan and the Furnace

Creek Fan. The probable maximum runoff will spread out over the fan; however, the sections indicate that 70 percent of the flow or 10,330 cubic feet per second will be channeled to the vicinity of the Headquarters Building. At the local drainage grade of three percent, this would be a stream 200 feet wide and four feet deep.

Recommendations for further study and flood mitigation: The apparent solution is to divert the flow to the north side of the Headquarters Wash Fan. Two diversion dikes would be required: one about 600 feet upstream of the Texas Spring Campground access road; and one just above the abandoned airstrip and trailer parking area to divert flows on the lower fan area. How these changes will affect the lower flows and local drainage around the trailer parking and the Visitor Center should also be examined.

FC-5 FURNACE CREEK INN RESULTS AND RECOMMENDATIONS

Results: The approximate locations of sections 5A and 5B are shown on the color photograph on page 22. Sections showing the flood depth and extent at 5A and 5B were prepared for four sets of conditions: 1) flows at the existing conditions, 2) flows from FC-5 only, 3) flows from FC-5 plus the 10-year flow from FC-6, and 4) all of the flow from FC-5 and FC-6.

1. Flows for existing conditions are the runoff from FC-5 plus any overflow from FC-6. Since there is no overflow from FC-6 at the 100-year flow, the entire flow for the 100-year runoff is from FC-5, which is 9,050 cubic feet per second (CFS). The probable maximum runoff will be the flow from FC-5 plus the overflow from FC-6 which will total approximately 90,000 CFS.

   Sections 5A and 5B on page 23 indicate that for the 100-year flow the roadway will be covered by about two feet and that water will be about two feet high at the service building. For the probable maximum flow, Section 5A shows a depth of eight feet over the roadway and a depth of over three feet at a vertical wall to protect the dormitories. Section 5B shows a depth of 8½ feet over roadway and around the service building. The motel-unit dormitories between Sections 5A and 5B would have about one foot of water at the 100-year flood and from five to six feet of water at the probable maximum flood.

2. Flows from FC-5 only is the runoff at the Inn if all of the flow from FC-6 is diverted into Gower Gulch. The flows are 9,050 CFS for the 100-year flow and 41,100 CFS for the probable maximum flow.

Sections 5A and 5B on page 24 indicate that for the 100-year flow the roadway will be covered by about two feet of water and that the water will be about two feet high at the service building. For the probable maximum flow, Section 5A shows a depth of five feet over the roadway with a threat of less than a foot to the dormitories; and Section 5B shows a depth of 5½ feet over the roadway and around the service building. Flow at the motel dormitories will be up to one foot for the 100-year flood and three feet for the probable maximum flood.

3. Flows from FC-5 and the 10-year flow from FC-6 would be the combined flow of 23,800 CFS for the 100-year flow and 55,850 CFS for the probable maximum flow. Sections 5A and 5B on page 25 indicate that for a 100-year flow the water will cover the roadway about three feet and will be about three feet high at the service building. For the probable maximum flood, Section 5A shows a depth of 6½ feet over the roadway and a depth of over one foot at a vertical wall protecting the dormitories; and Section B shows a depth of 6½ feet over the roadway and around the service building. Flow at the motel-unit dormitories will be one to two feet deep for the 100-year flood and three to four feet deep for the probable maximum flood.

4. All the flow from FC-5 and FC-6 would be 27,000 CFS for the 100-year flood and 90,000 CFS for the probable maximum storm. Sections 5A and 5B on page 26 indicate that for a 100-year flow the water will cover the roadway about four feet and be about four feet deep around the service building. For the probable maximum flood, Section 5A shows a depth of eight feet over the roadway and a depth of over three feet at a vertical wall protecting the dormitories. Section B shows a depth of 8½ feet over the roadway and around the service building. The motel-unit dormitories between Section 5A and 5B will have about two feet of water for the 100-year flood and five to six feet of water for the probable maximum flood.

Recommendations: Regardless of who is responsible for the protection of life and property, some flood precautions and mitigation should be made. Some type of advance warning should be available to employees at the service building at Section 5B; a low retaining wall should be constructed for the employee dormitories; and the use of the motel-unit dormitories should be phased out or used for storage.

FC-5 FURNACE CREEK WATER INTAKE RESULTS AND RECOMMENDATIONS

Results: The locations of Sections 5C through 5G are indicated on page 27 and page 28. Sections showing flood depths and extents at 5A through 5G for the flow from FC-5 plus the 10-year flow from FC-6 are on pages 29 through 33 . For comparison, flood depths and extents at Section 5E for the flow at existing conditions, flow from FC-5 only, and all the flow from FC-5 and FC-6 combined are shown on pages 34 through 36 . Page 28 is a plan of the flood extents for the flow from FC-5 plus the 10-year flow from FC-6.

For the combined flow from FC-5 plus 10-year flow from FC-6, the flow will be seven feet deep, and all the intake features within the wash including the collection lines, headwalls, overflow, overflow percolation lines, and the collection box will be washed out during a major flood of 100-year frequency or longer. Also for this combined flow, runoff from storms of only 5 to 10-year frequency could cause problems to the sump line and overflow by scouring out the lines and by dumping silty water into the overflow. The probable maximum flow will be 10½ feet deep which will endanger the highway by washing out the embankment.

At Section 5E the flow for existing conditions will be 4½ feet deep for the 100-year flood which will destroy the water intake features within the wash, and the probable maximum flood will be 13½ feet deep which will also inundate and wash out the highway.

The flow from only FC-5 at Section E for the 100-year flood will be 4½ feet deep which would destroy the intake features within the wash, and the probable maximum flood will be nine feet deep, which will endanger the highway.

The flow from FC-5 and all of FC-6 combined at Section E for the 100-year flood would be 7½ feet deep which would destroy the intake features within the wash, and the probable maximum flood would be 13½ feet deep which will inundate and wash out the highway.

Recommendations: For the 100-year flood flow from FC-5 and the 10-year flow from FC-6 combined, a diversion dike 10 feet high should be constructed around the collection box in the wash. An eight-foot dike around the sump collection lines and headwall should be examined for feasibility and cost effectiveness. The sump line overflow should be connected to a new line which can be daylighted within the protective dike for the collection box. No protection for the stilling well and percolation trench for the collection box overflow line should be provided. Complete protection cannot be constructed since the percolation trench extends across the width of the wash. Also, destruction of the stilling well and percolation trench will not affect the collection system.

For the existing conditions and for diverting all of the flow from FC-6 down Gower Gulch, a diversion dike four feet high around the collection box would be required.

For the intake area, the best solution is to divert as much of FC-6 as possible from entering FC-5. Possibly, a flow from FC-6 of up to the 2 to 5-year maximum would protect the intake and allow sufficient water resource rejuvenation.

FC-6 ZABRISKIE POINT RESULTS AND RECOMMENDATIONS

Results: The map on page 8 shows the entire 188 square-mile FC-6 area. Also, pages 9 through 12 show reduced USGS quadrangle sheets with topography of the FC-6 area. Page 37 is a reduction of a portion of Drawing Number 143-41092 of the Zabriskie Area and gives the locations of Sections FC-6A through FC-6E which are on pages 38 through 42.

The 100-year flood will be contained within the Furnace Creek wash and will be diverted down Gower Gulch. A small amount of flow from the upper portion of Zabriskie Wash to the east side of Highway 190 will remain on the east side of the highway and not be diverted into Gower Gulch; however, the flow should be insignificant.

The probable maximum flood down Furnace Creek Wash may barely be contained south of the highway as shown on Sections FC-6A, 6B, and 6C. The high velocity of flood water on the road embankment, however, will most likely wash out the highway. Gower Gulch will contain and divert approximately 39,000 CFS from Furnace Creek Wash and approximately 50,000 CFS will overflow Gower Gulch and continue down Furnace Creek Wash as indicated by the flood extent map on page 37. Large flows up to 15,000 CFS can be expected to flow down Zabriskie Wash as part of a maximim storm in that portion of the drainage and this flow would wash out Highway 190 at the wash and highway crossing.

Recommendations: The objective at Zabriskie Point is to have all flow from the Furnace Creek Wash drainage basin (FC-6) continue down Furnace Creek Wash up to the 10-year flood runoff. Runoff in excess of the 10-year flow of 14,750 CFS will be diverted down Gower Gulch. To accomplish the above requirements, it is recommended that all the flow from Furnace Creek Wash be intercepted by a channel located between Sections 6A and 6B. The channel will be constructed at a low gradient to prevent abrasion of the channel lining and to contain a flowing capacity of 14,750 CFS. Any flow in excess of 14,750 CFS will flow over the channel and continue down the wash and be diverted into Gower Gulch. The channel will continue down the wash and cross Zabriskie Wash just south of Highway 190. Again, flow will cross the channel and flow in excess of 14,750 CFS will spill over the channel and continue into Gower Gulch. The channel will then continue down to the north of the Zabriskie Point access trail and terminate. The flow will then follow natural wash channels down Furnace Creek. Gower Gulch capacity will have to accommodate 75,000 CFS and should be widened. The highway at the Zabriskie Wash crossing should be designed to withstand large flows and may require some grade and horizontal realignment to direct flow into the Furnace Creek channel which bypasses Gower Gulch. A bridge or dip will be required where the channel crosses the Zabriskie Point access trail.

The channel will have sloping sides of one or two or flatter so that animals and humans will not fall into, or be trapped within the channel.

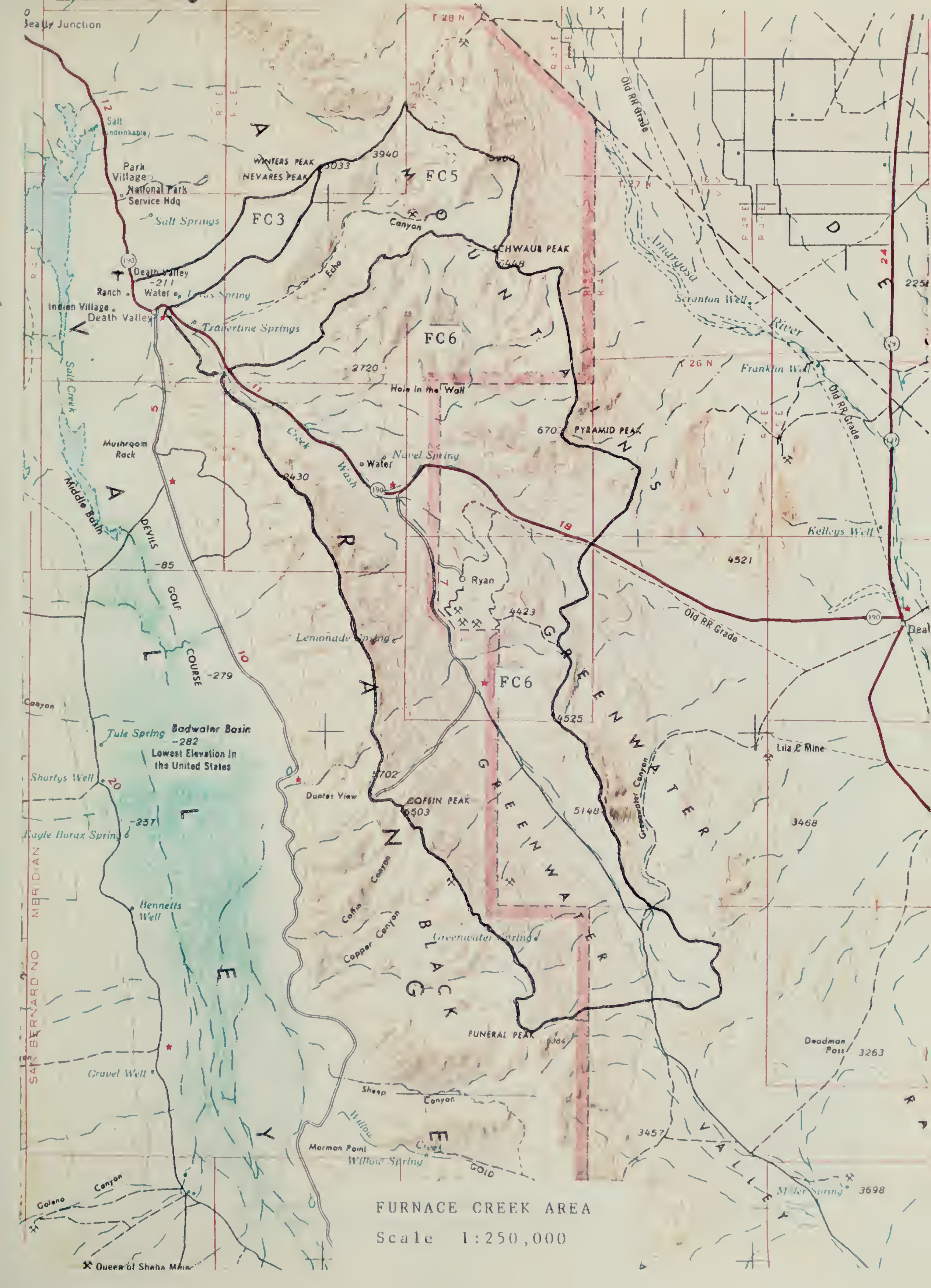
The channel will most likely be constructed of concrete and will have a wide bottom for removing sediment by machinery.

The above assumptions could be changed to accommodate up to the 2 or 5 year flood flow from FC-6, which would substantially reduce the cost of flood mitigation downstream at the Furnace Creek water intake.

FC-5 INDIAN VILLAGE RESULTS AND RECOMMENDATIONS

Results: The location of the Indian Village is on the lower portion of the Furnace Creek Fan as indicated on page 8. The flow from FC-5 will spread out over the fan and could affect the Indian Village, especially if the flow becomes channelized.

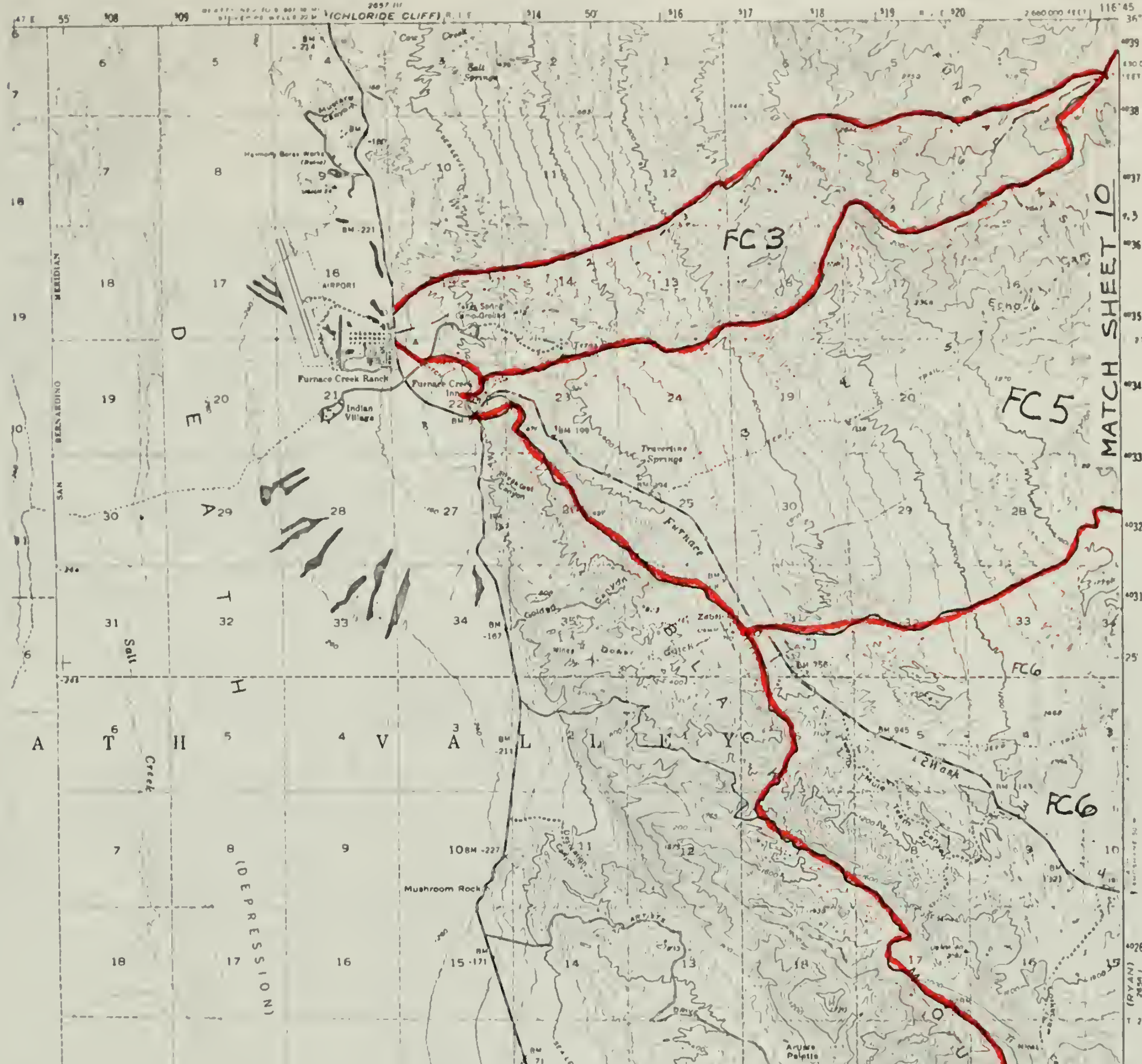
Recommendations: To prevent flood waters from entering the Indian Village, a low dike could be constructed above the village to divert floodwaters to the south of the village.



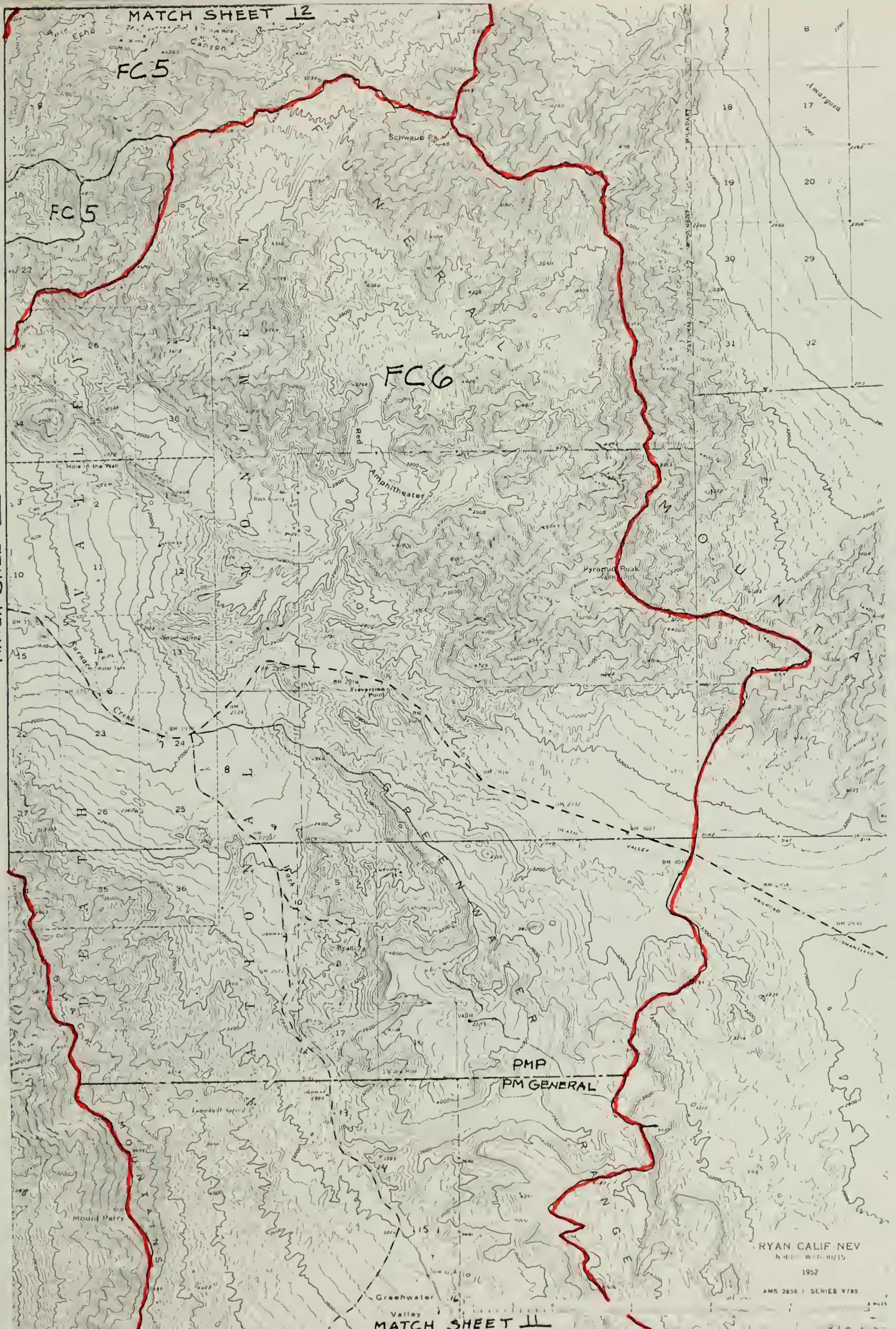
FURNACE CREEK AREA

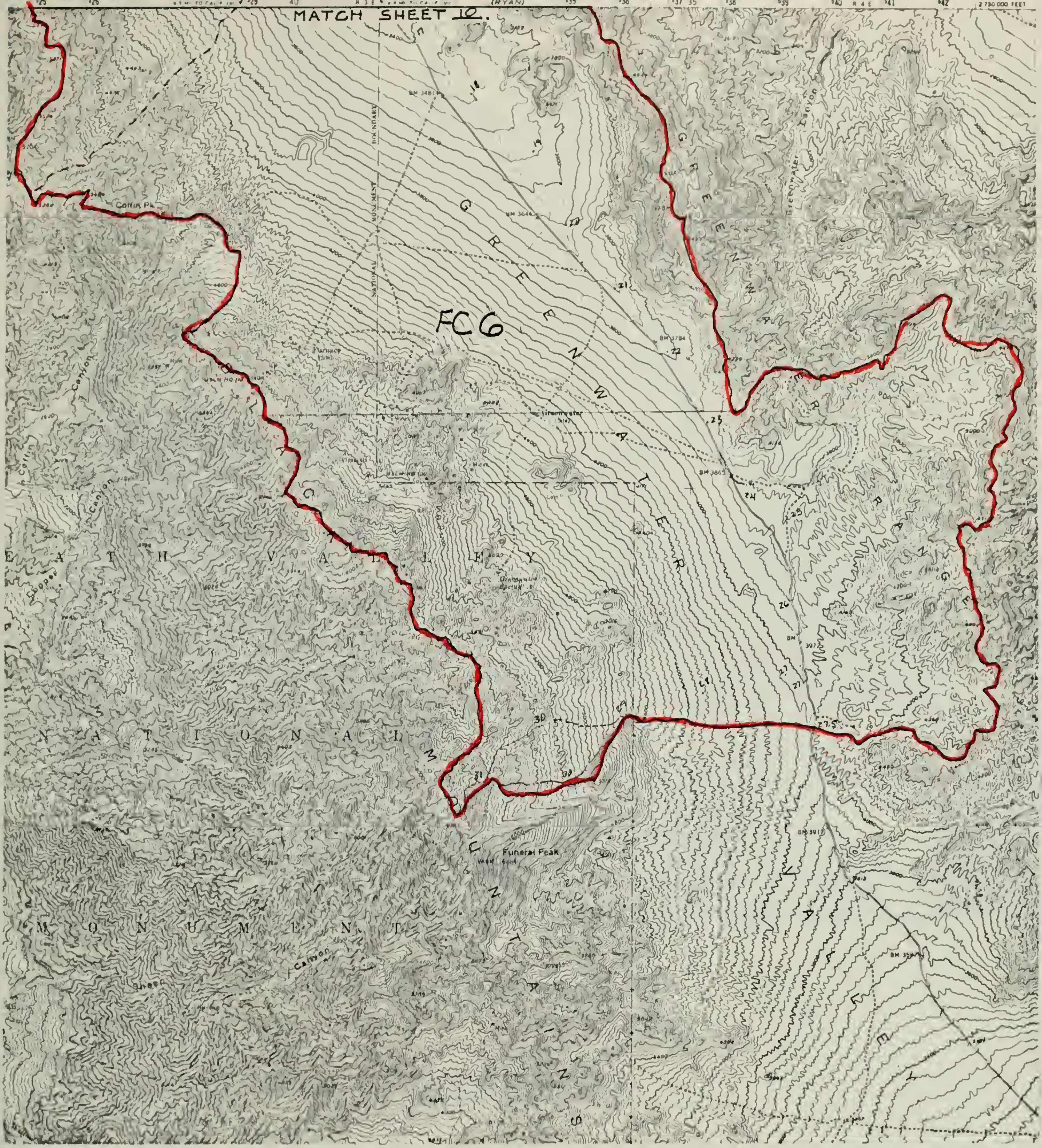
Scale 1:250,000

FURNACE CREEK QUADRANGLE
CALIFORNIA-INYO CO
15 MINUTE SERIES (TOPOGRAPHIC)



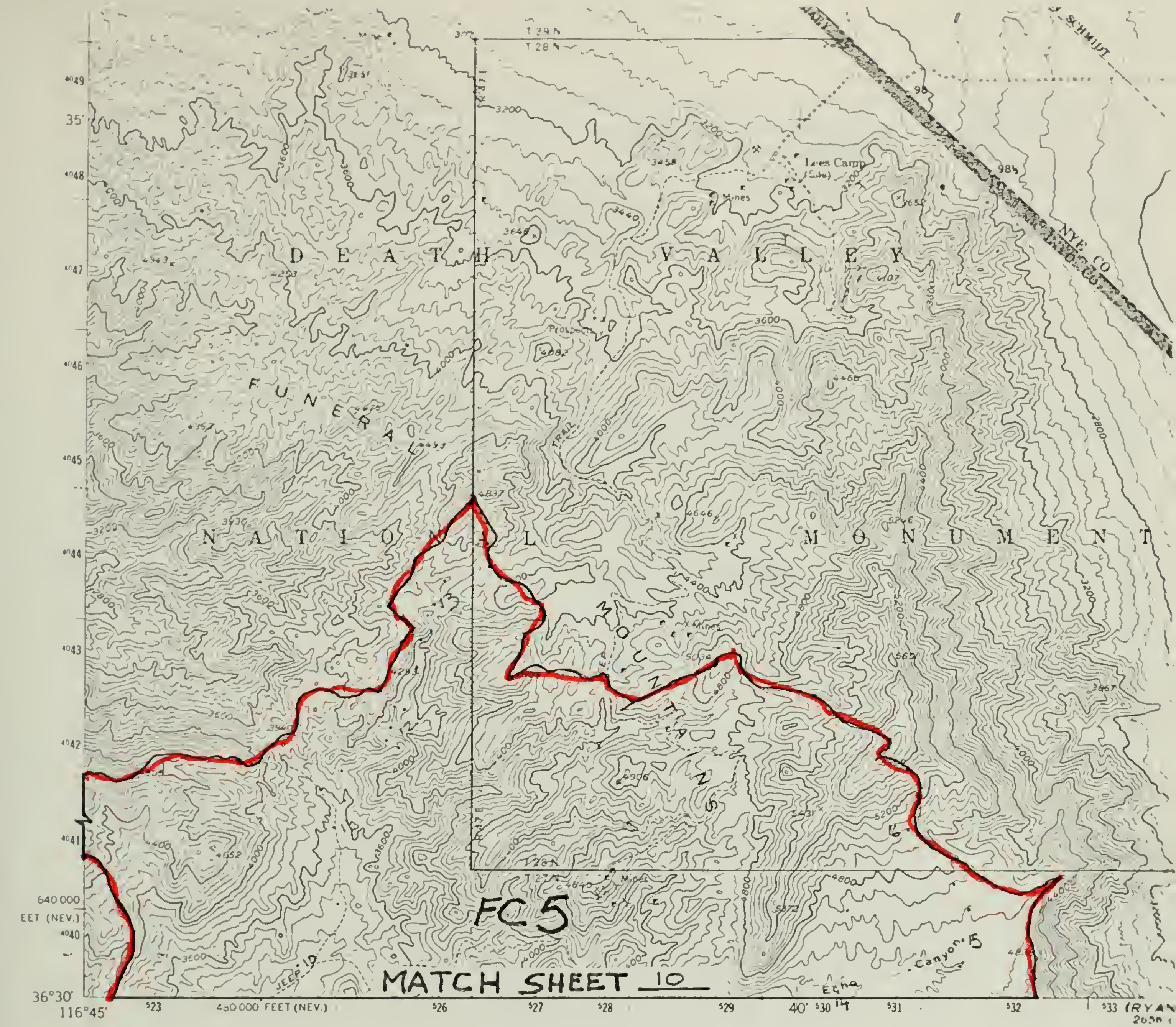
FURNACE CREEK, CALIF.
N3615—W11645/15
1952


MATCH SHEET 12
FC5
FC5
FC6
MATCH SHEET
MATCH SHEET 11
PMP
PM GENERAL
Echo Canyon
Schwaub Pk
Red Amphitheater
Hole in the Wall
Rock quarry
Furnace Creek
Travertine Point
Pyramid Peak
Ryan
Greenwater Valley
Mount Perry
Amargosa
RYAN CALIF NEV
1952
AMS 2650 I SERIES V795



FUNERAL PEAK, CALIF.
N3600—W11630/15

1951



BIG DUNE, NEV.—CALIF.

N3630—W11630/15

SCALE 1 62500

FORM D S C - 44

Park DEATH VALLEY **Area** FURNACE CREEK	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 13 **of**
Project	**By** DEB / **Checked**	**Pkg.**
Feature	**Date** 5/2- 8- / **Date**	**Account**

TABLE I - DRAINAGE AREAS CHARACTERISTICS

AREA NAME	AREA (Miles^2)	LENGTH (MILES)	TIME OF CONC. (MIN.)	ELEV. MAX. (FT.)	ELEV. MIN. (FT.)	AVE CHANNEL SLOPE
FC-23 Cow Creek School	0.40	2.25	29.7	720	-120	0.071
FC-3 HQ Wash	6.05	7.4	62.0	4213	-180	0.106
FC-5 Furnace Cr. Inn	39.38	16.2	145	5200	00	0.061
FC-6 Zabriski Point General Storm	188.17	27.5	313	4050	670	0.023
FC-6 PMP Storm	100	12.5	116	4800	670	0.063

* Formula for Time of Concentration = $T_c = \left(\frac{11.9 \cdot L^3}{\Delta E}\right)^{.385}$

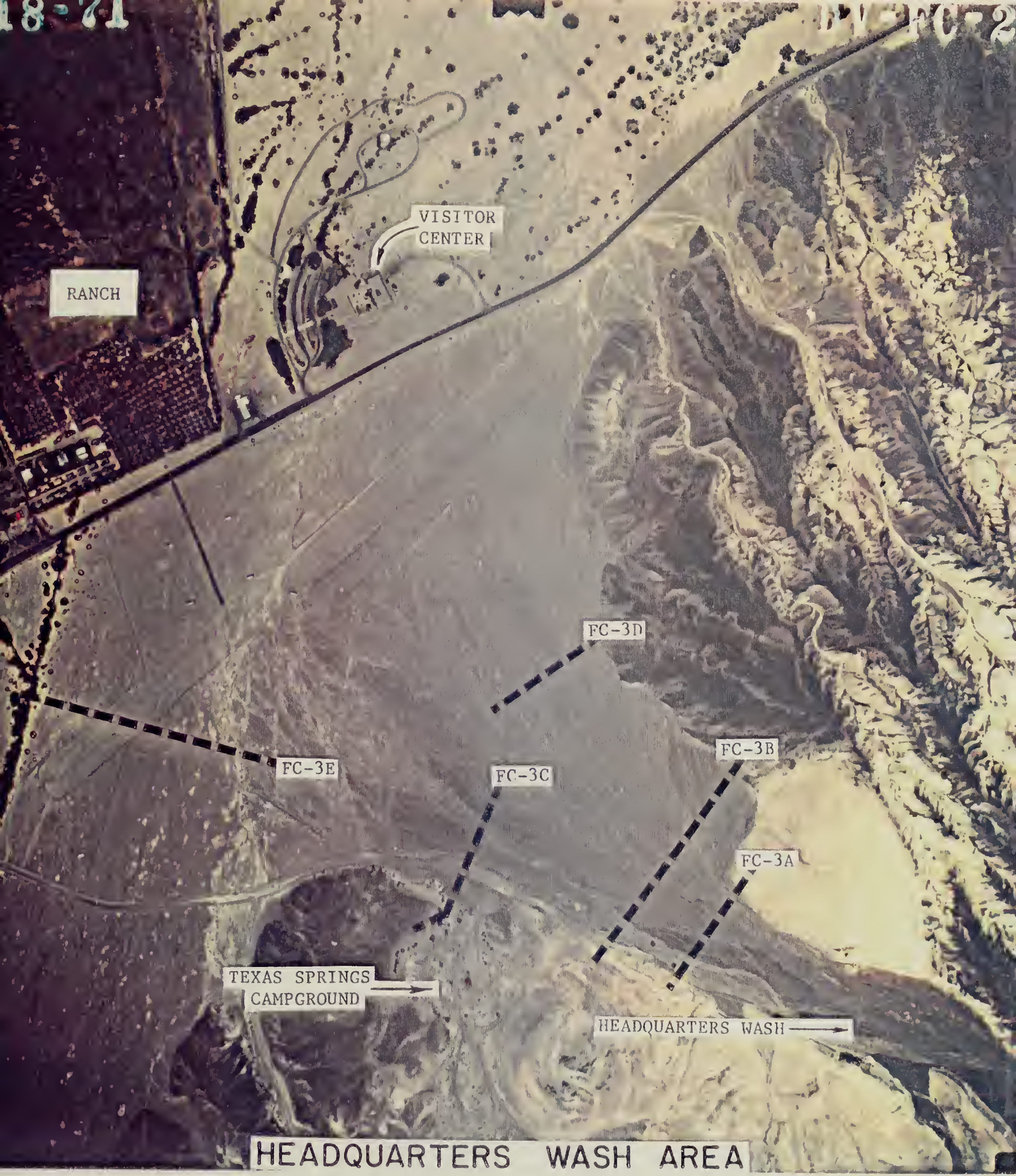
L = Length in Miles; ΔE = Diff. in Elev. in Ft.

Tc in hours.

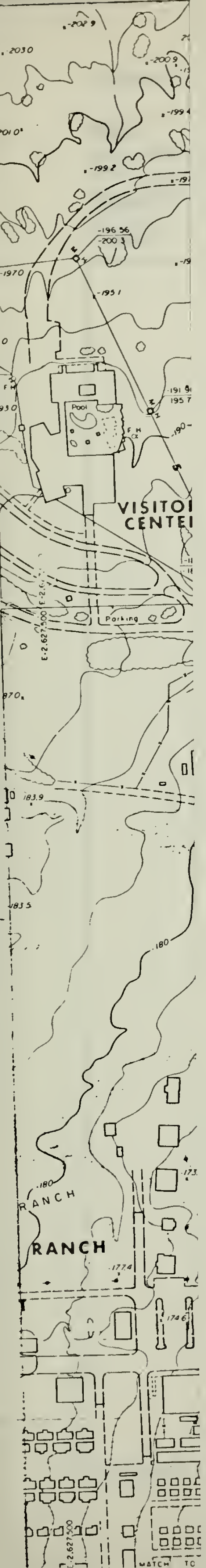
•U.S. GPO: 1984-778-378

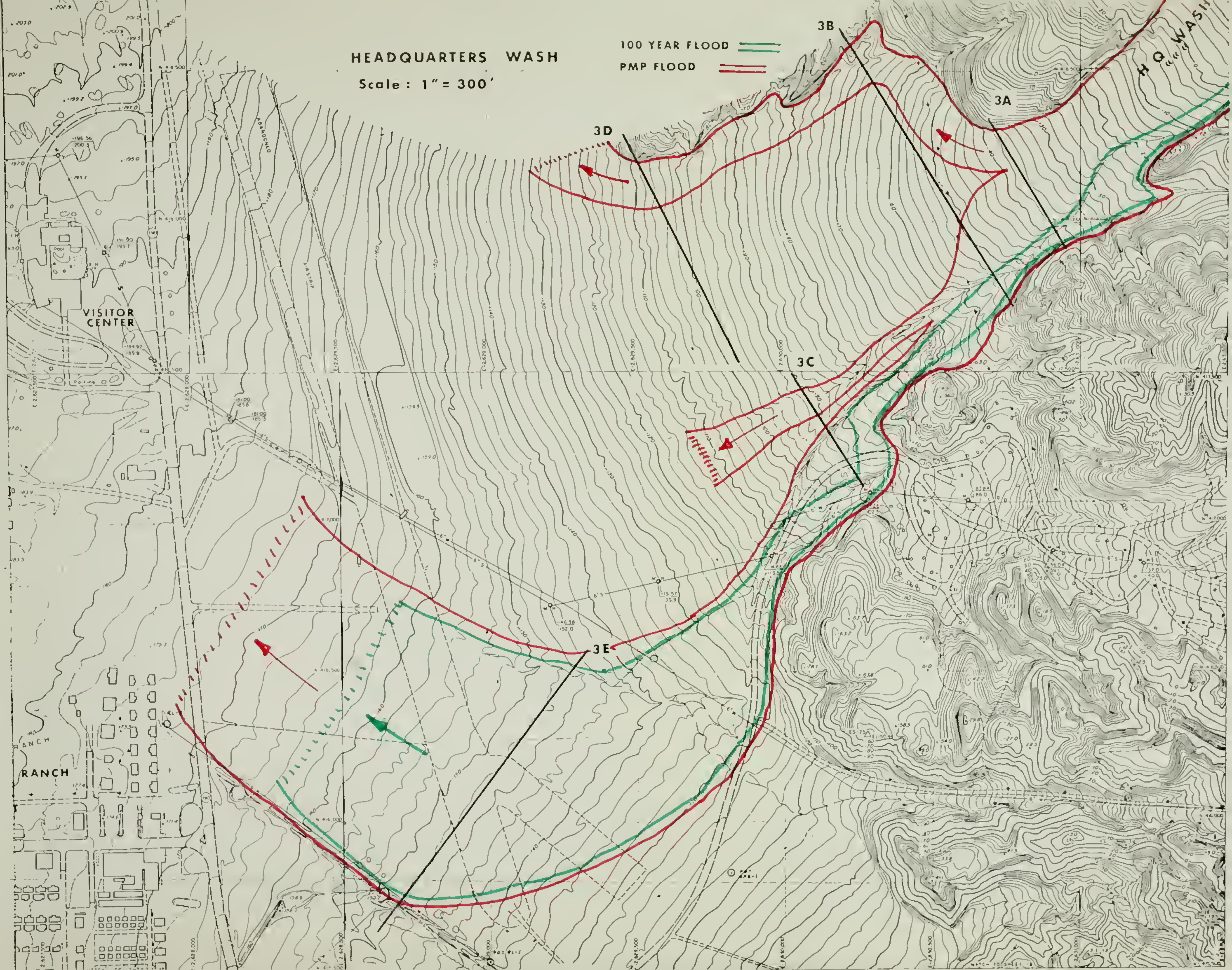
TABLE 2 - PRECIPITATION & RUNOFF

AREA NAME	FC-3 HQ WASH	FC-5 FURNACE CREEK INN	FC-5, 6: FC-5 + 10 YR. ZAB. OVFL.	FC-6 ZABRISKIE PT.
FREQ.-DURATION	INCHES	INCHES	INCHES	INCHES
10 YR. PRECIP.				
30 MIN.				0.36
1 HR.				0.64
2 HR.				0.73
3 HR.				0.85
6 HR.				1.08
12 HR.				1.67
24 HR.				2.02
100 YR. PRECIP.				
30 MIN.	0.78	0.67		0.54
1 HR.	1.00	0.96		0.80
2 HR.	1.13	1.26		1.20
3 HR.	1.24	1.45		1.22
6 HR.				1.62
12 HR.				2.23
PMP PRECIP.				
30 MIN.	3.97	–		–
1 HR.	5.6	4.14		3.09
1.5 HR.	6.55	4.84		3.62
2 HR.	7.06	5.22		3.89
2.5 HR.	-	5.44		4.06
3 HR.		5.55		4.14
GENERAL TYPE STORM				
3 HR				1.55
6 HR				2.46
8 HR.				2.90
10 HR.				3.35
12 HR.				3.76
14 HR.				4.08
10 YEAR RUNOFF				14,750 CFS
100 YEAR RUNOFF	2,400 CFS	9,050 CFS	23,800 CFS	23,000 CFS
PMP RUNOFF	14,400 CFS	41,100 CFS	55,850 CFS	89,200 CFS
GENERAL STORM MAX. RUNOFF				36,500 CFS



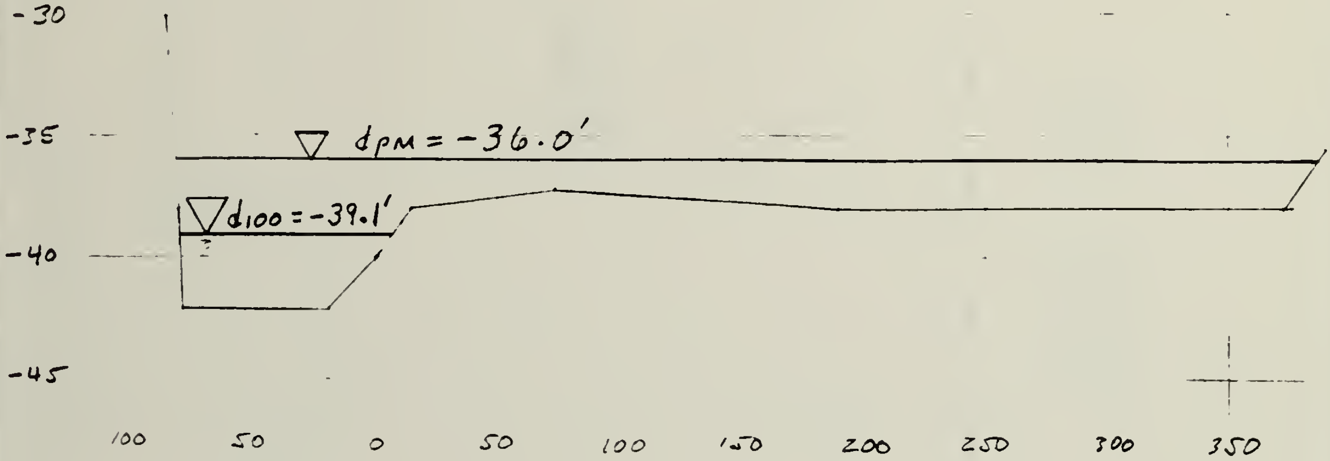
HEADQUARTERS WASH AREA


-202.9
-2030
-200.9
-199.4
-199.2
-196.56
-200.3
-1970
-195.1
-191.9
-195.7
-190
Pool
F.H.
VISITO
CENTE
E-2,627,500
Parking
183.9
183.5
180
180
RANCH
RANCH
-177.4
174.6
E-2,627,500
MATCH TO


HEADQUARTERS WASH
Scale : 1" = 300'
100 YEAR FLOOD
PMP FLOOD
H Q WASH
3A
3B
3C
3D
3E
VISITOR CENTER
RANCH
Pool
Parking

FORM D S C - 44

Park DEATH VALLEY N.M		**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	Sheet 17
Area HEADQUARTERS [illegible]			of
Project	By E S	Checked	Pkg.
Feature SECTION [illegible] 3	Date [illegible]	Date	Account

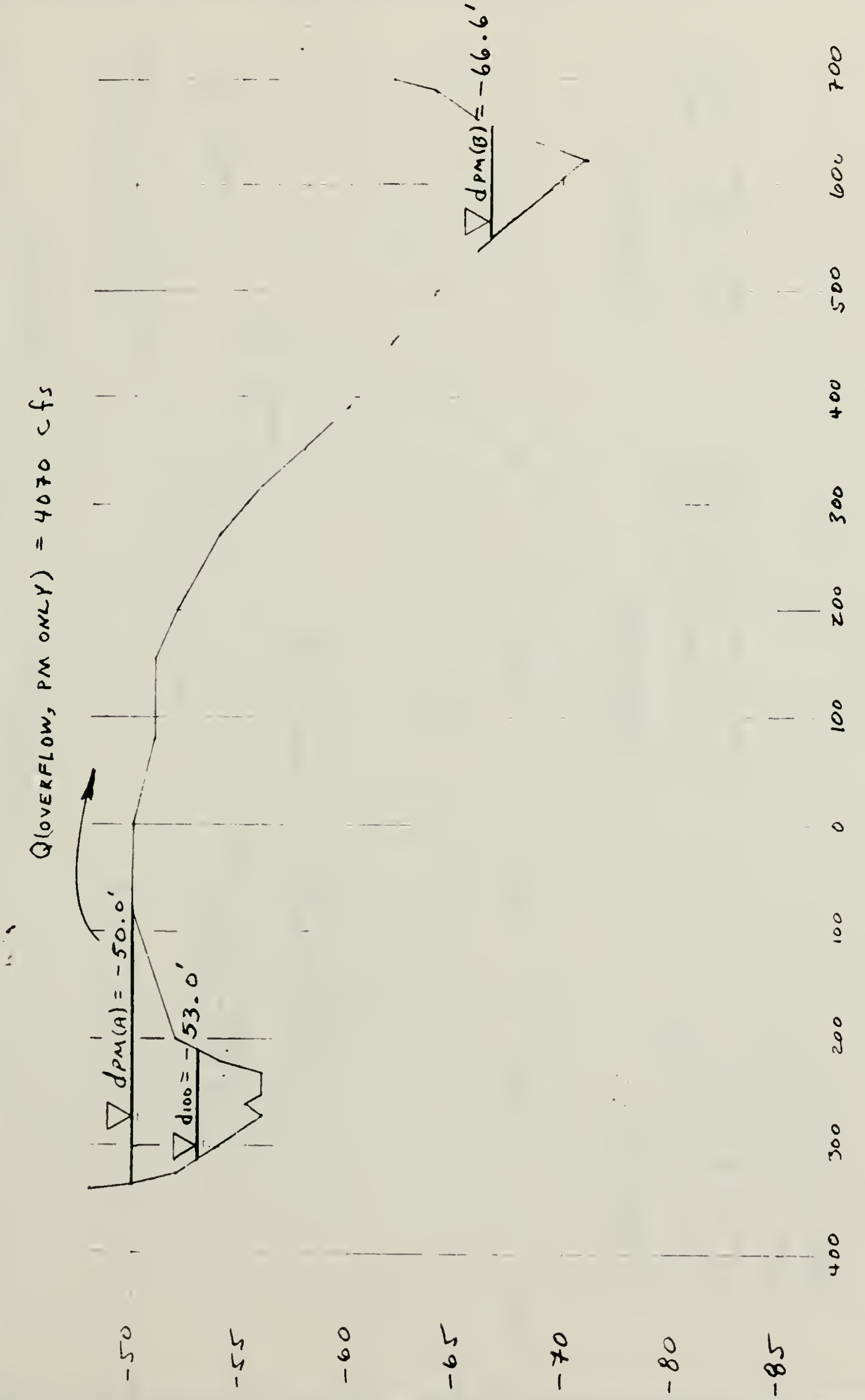


Q100 = 2400 cfs
V100 = 11.2 fps

QPM = 14,400 cfs
VPM = 11.8 fps

FORM D S C - 44

Park DEATH VALLEY N.M. Area HEADQUARTERS AREA	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 18 of
Project	By R. G.	Checked	Pkg.
Feature SECTION FC- 3B	Date 6/28/84	Date	Account



$V_{PM(A)}$ = 14.8 fps

$V_{PM(B)}$ = 14.7 fps

Q_{100} = 2400 cfs

V_{100} = 11.7 fps

$Q_{PM(A)}$ = 10,330 cfs

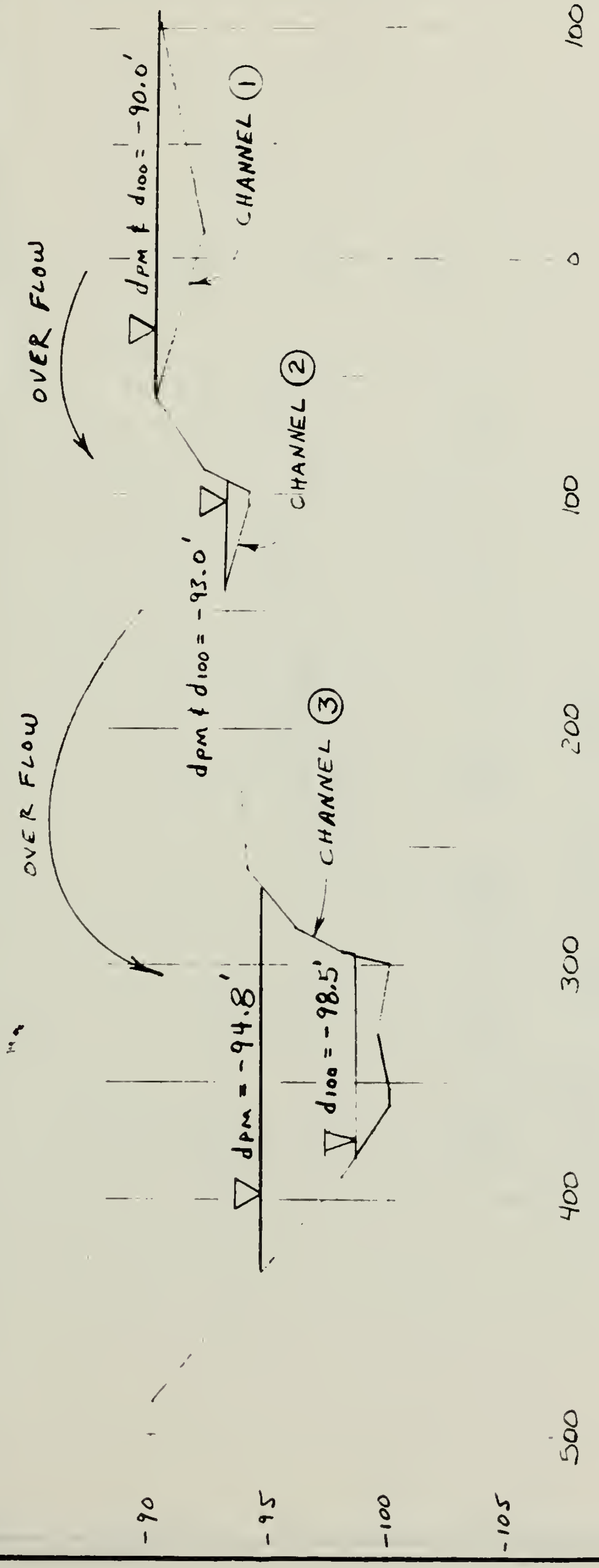
$Q_{PM(B)}$ = 4070 cfs

$Q_{PM(TOTAL)}$ = 14,400 cfs

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 19
Area HEADQUARTERS WASH			of
Project	By R. G.	Checked	Pkg.
Feature SECTION FC-3C	Date 6/28/84	Date	Account



CHANNEL ①

$Q_{100} = Q_{PM} = 1200$ cfs

$V_{100} = V_{PM} = 7.8$ fps

CHANNEL ②

$Q_{100} = Q_{PM} = 125$ cfs

$V_{100} = V_{PM} = 5.0$ fps

CHANNEL ③

$Q_{100} = 1075$ cfs

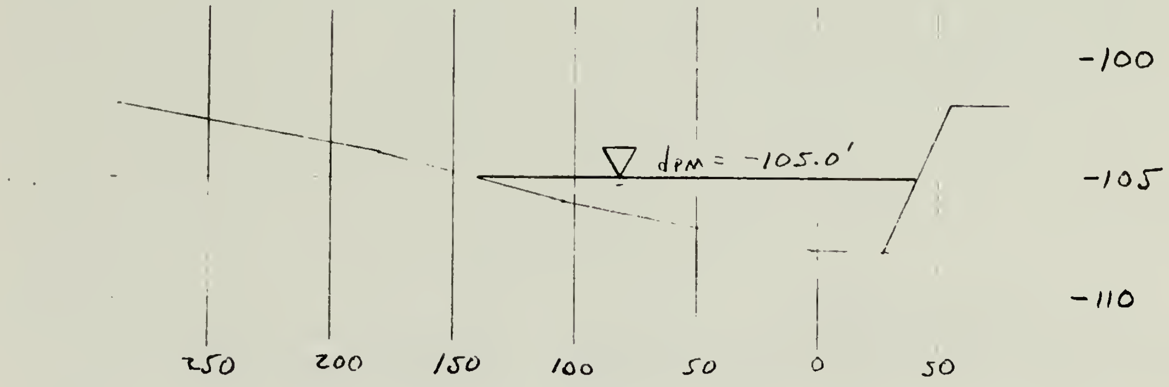
$V_{100} = 9.7$ fps

$Q_{PM} = 9000$ cfs

$V_{PM} = 16.6$ fps

FORM D S C - 44

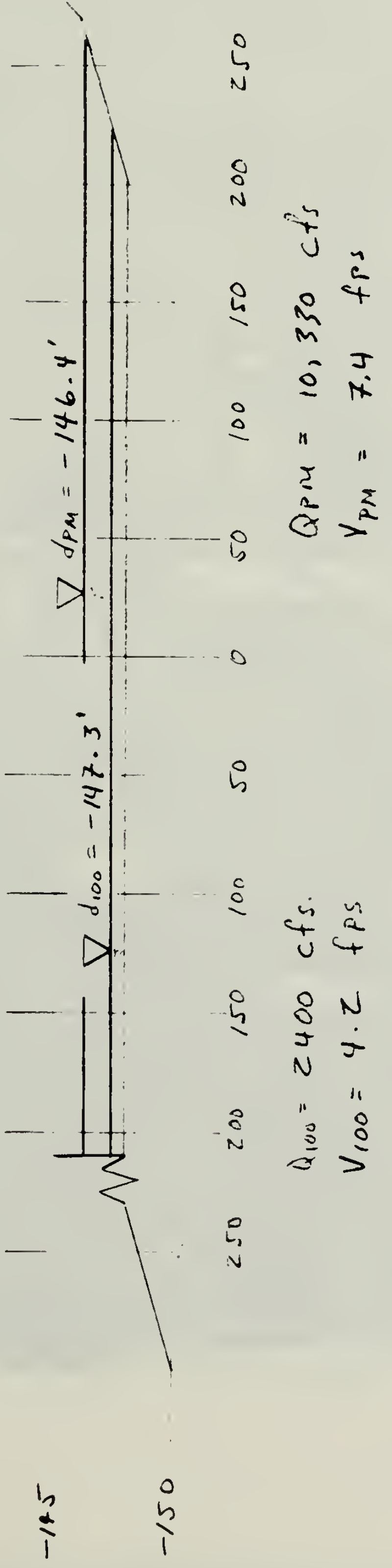
Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 20
Area HEADQUARTERS WASH			**of**
Project	**By** Z.G.	**Checked**	**Pkg.**
Feature SECTION FC-3D	**Date** 6/28/84	**Date**	**Account**

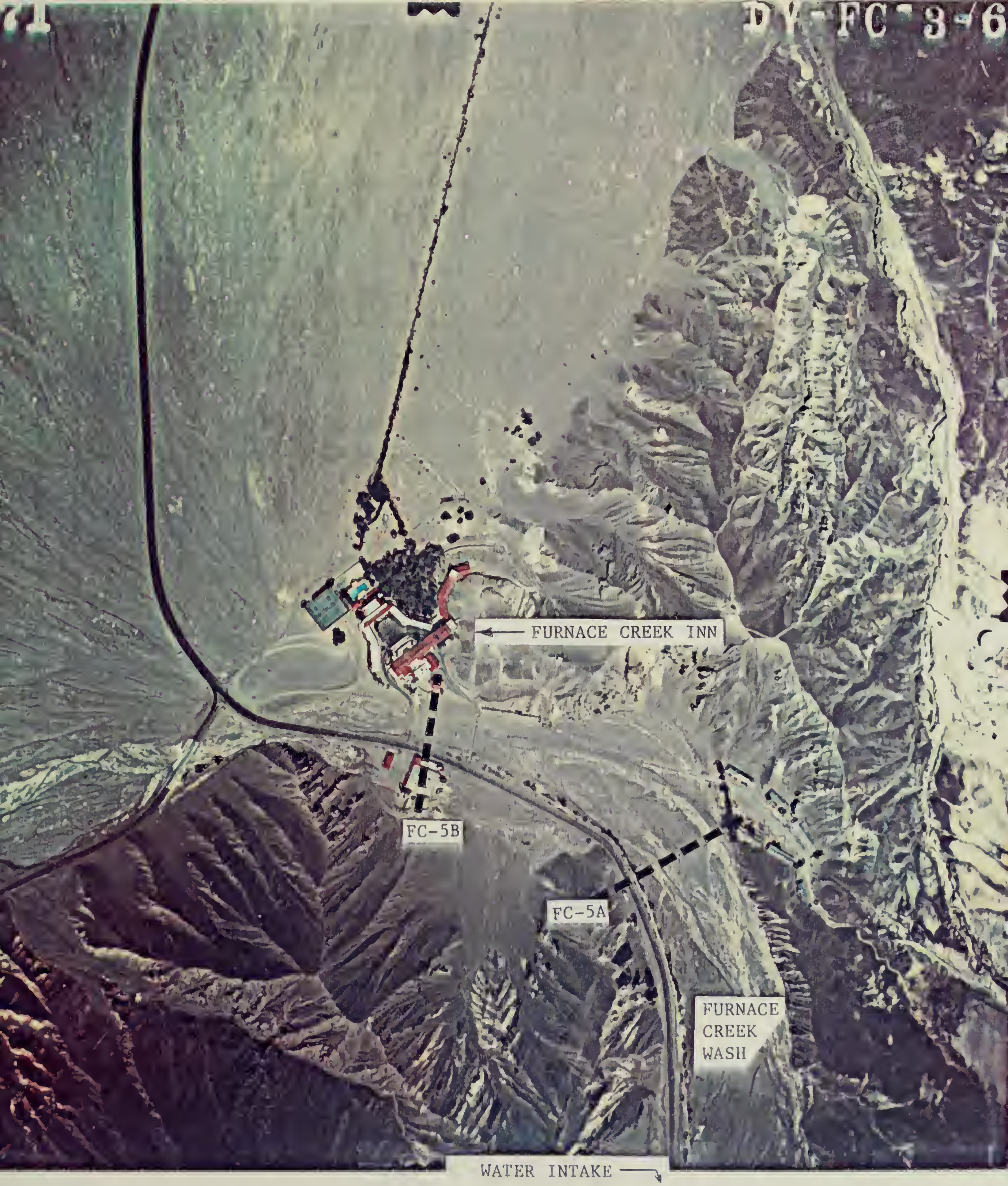


NOTE: PM FLOW ONLY
$Q_{PM} = 4070$ cfs
$V_{PM} = 11.2$ fps

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 21
Area HEADQUARTERS WASH			**of**
Project	**By** Z G.	**Checked**	**Pkg.**
Feature SECTION FC - 3E	**Date** 6/20/84	**Date**	**Account**

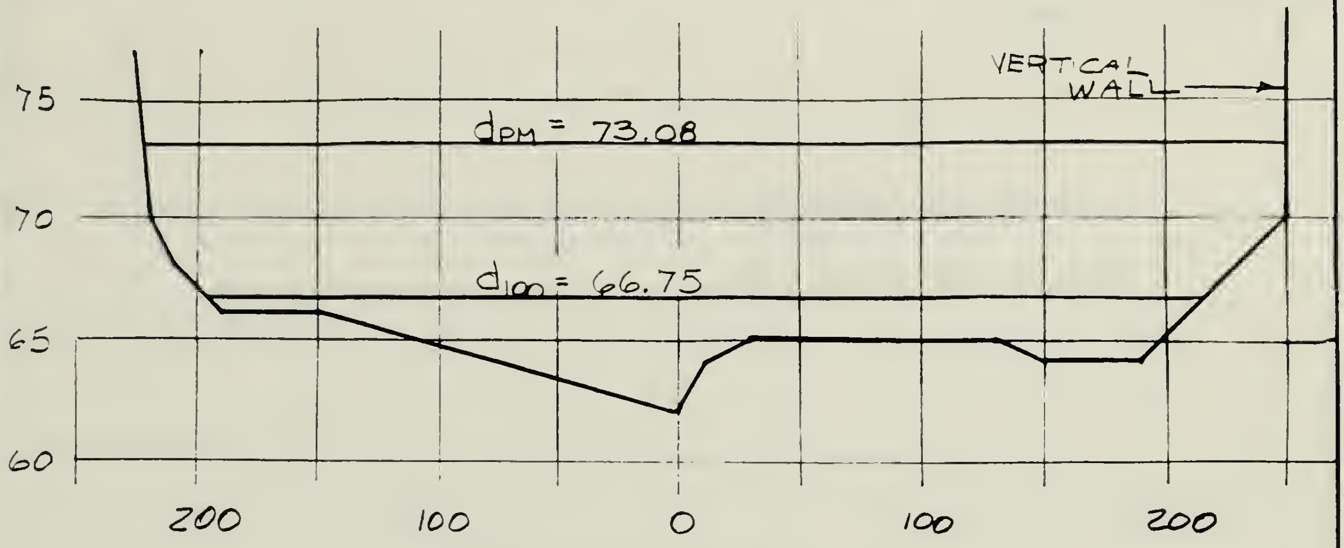




FURNACE CREEK INN AREA FC-5

FORM D S C - 44

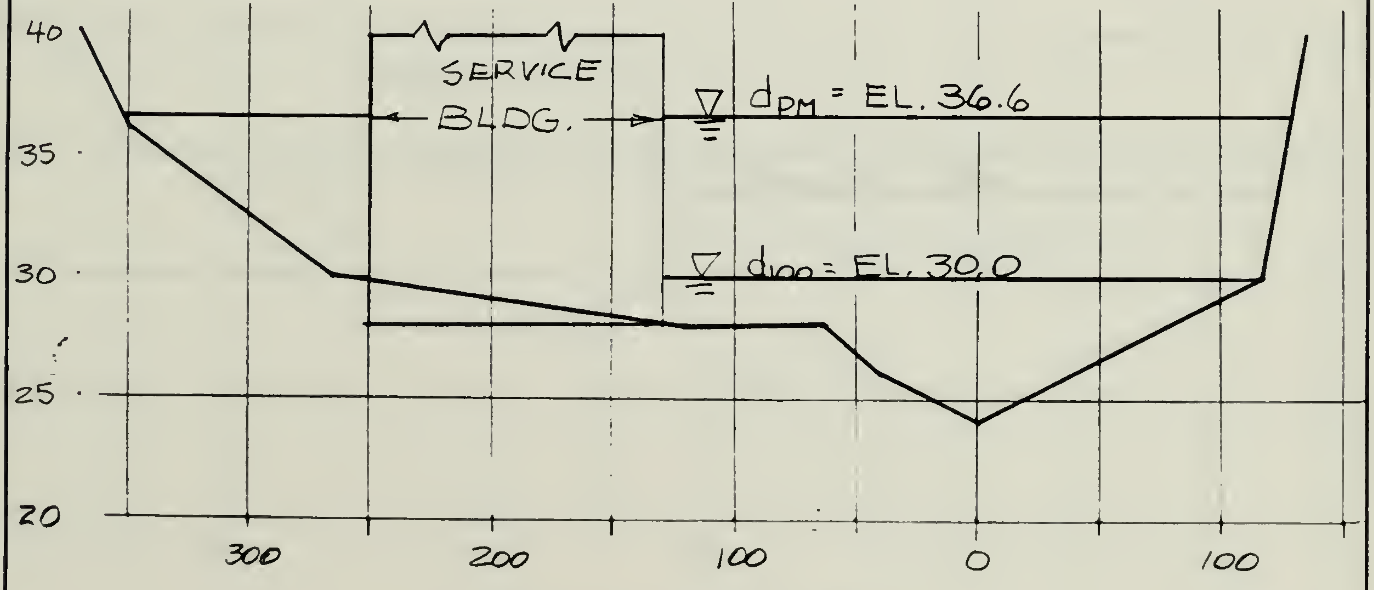
Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 23
Area			of
Project	By	Checked	Pkg.
Feature FLOW AT EXISTING CONDITIONS	Date	Date	Account



SECTION 5A

Q_{100} = Flow from FC-5 on i = 9,050 CFS

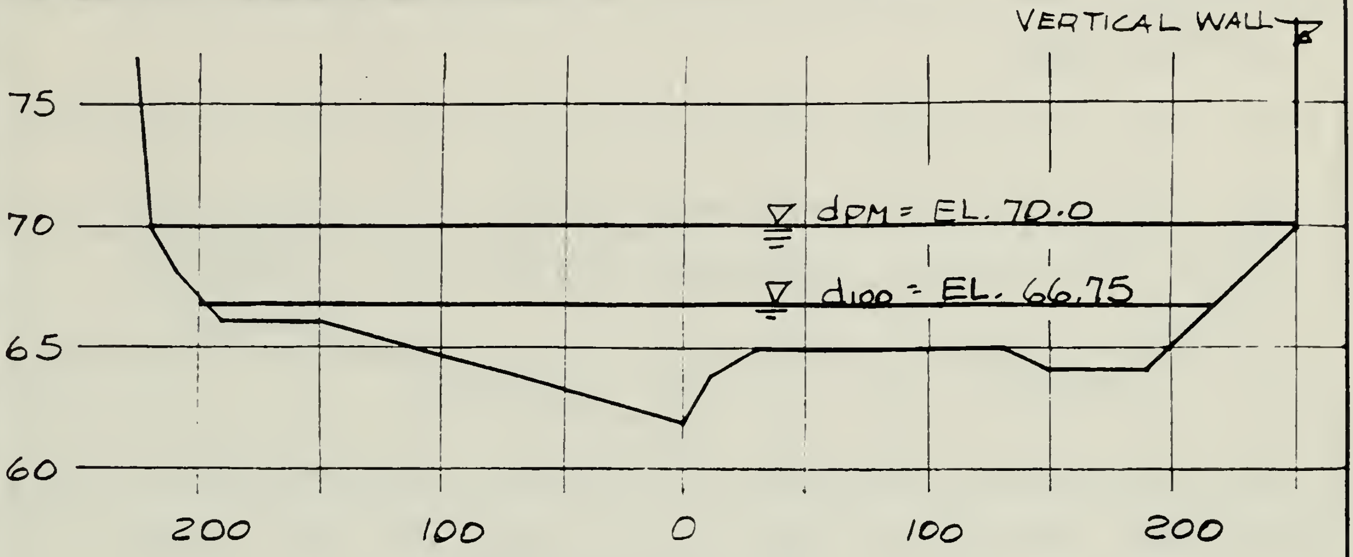
Q_{PM} = Flow from FC-5 plus overflow from FC-6 = 90,000 cfs



SECTION 5B

FORM D S C - 44

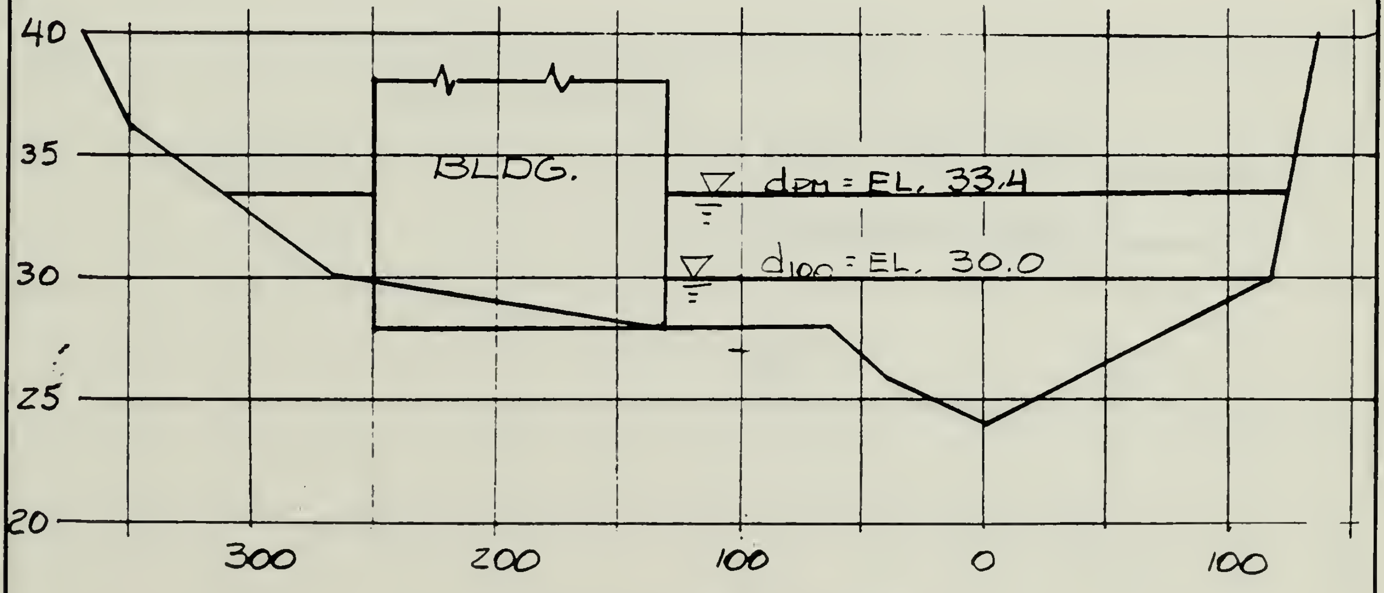
Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 24
Area			**of**
Project	**By**	**Checked**	**Pkg.**
Feature FLOW WITH ALL OF FC-6 DIVERTED DOWN GOWER GULCH	**Date**	**Date**	**Account**



SECTION 5A

Q_{100} = Flow from FC-5 Only (No FC-6) = 9,050

Q_{PM} = Flow from FC-5 Only (No FC-6) = 41,100 CFS

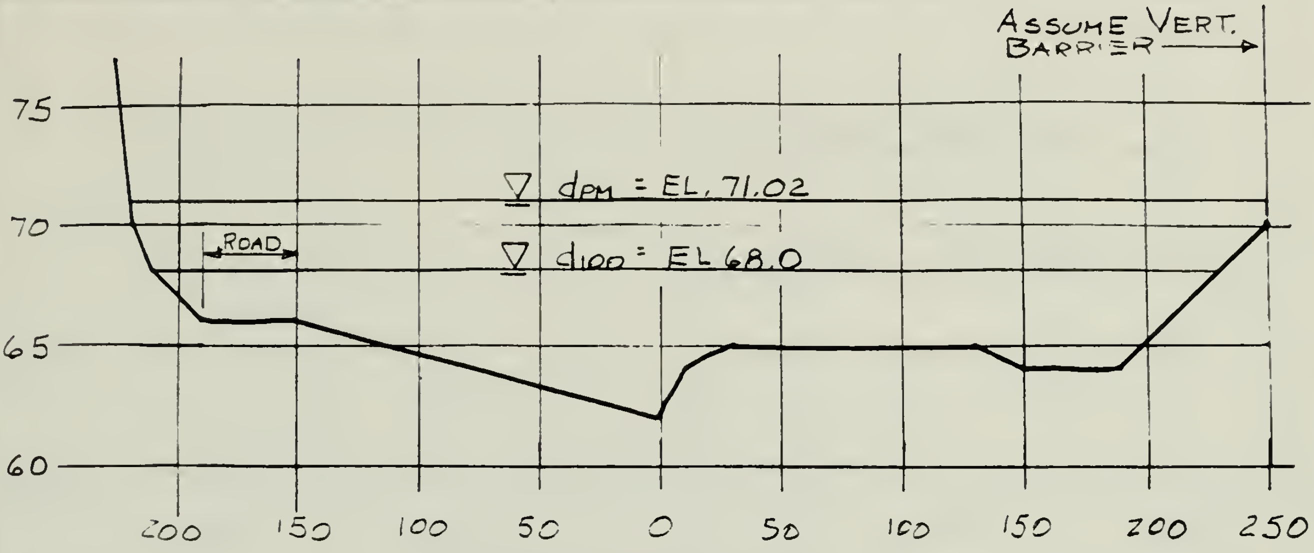


SECTION 5B

•U.S GPO: 1984-778-378

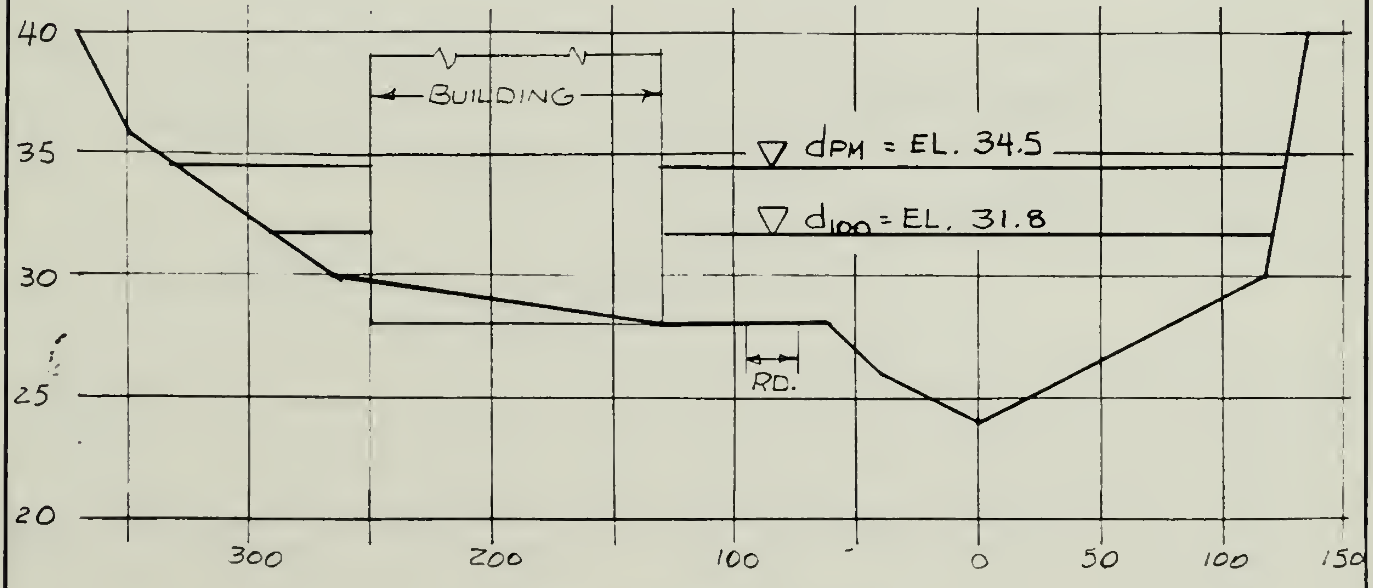
FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 25
Area			**of**
Project	**By** RFB	**Checked**	**Pkg.**
Feature FLOW FROM FC-5 PLUS THE 10-YEAR FLOW FROM FC-6	**Date** 12/84	**Date**	**Account**



SECTION 5A

Q_{100} = 23,800
Q_{PMP} = 55,850



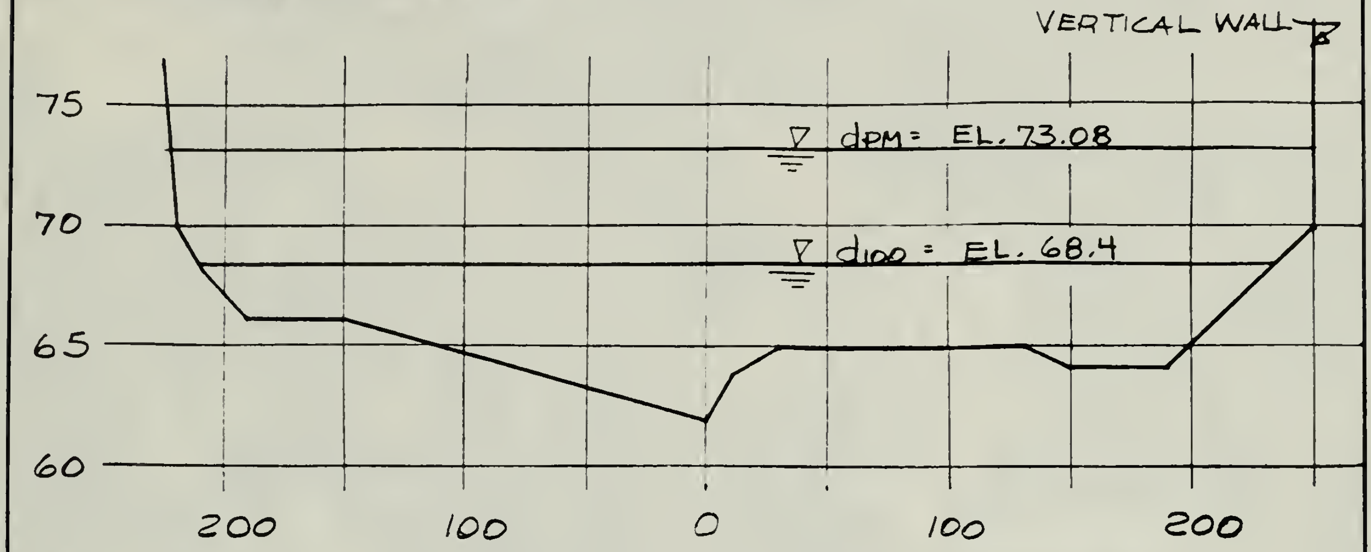
SECTION 5B

Q_{100} = 23,800 CFS
Q_{PM} = 55,850 CFS

•U.S. GPO: 1984-778-378

FORM D S C - 44

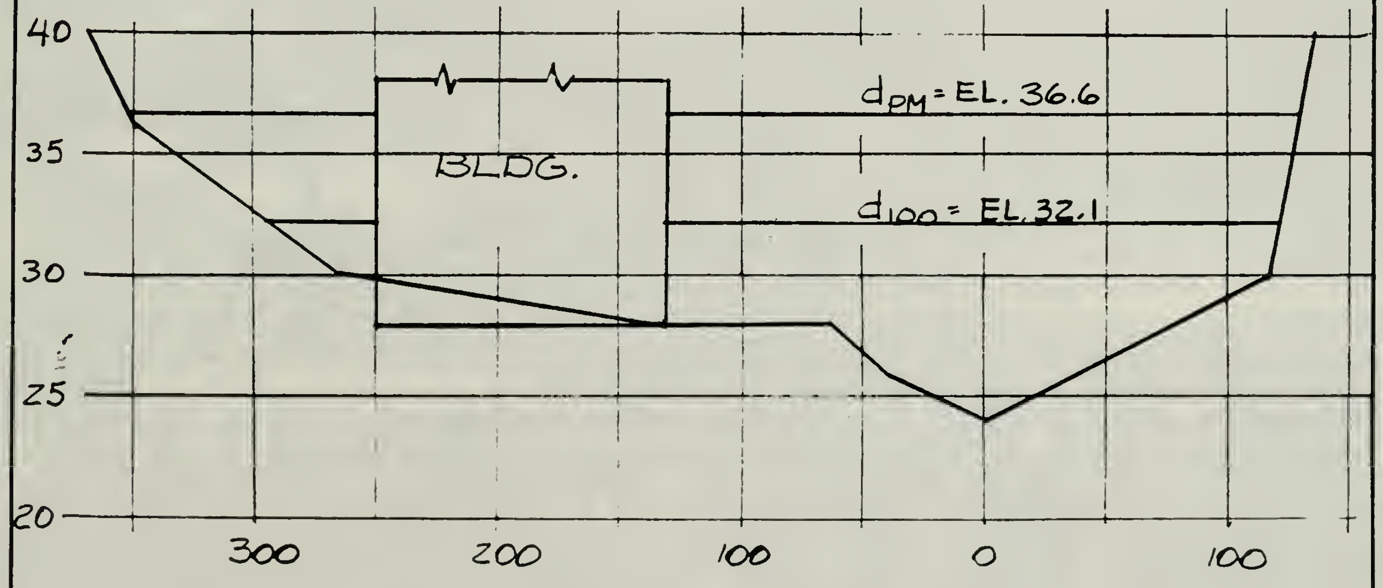
Park	**NATIONAL PARK SERVICE** DENVER SERVICE CENTER		Sheet 26
Area			of
Project	By	Checked	Pkg.
Feature FLOW AT ALL OF FC-5 & FC-6 (FC-6 DOWN FURNACE CR.)	Date	Date	Account



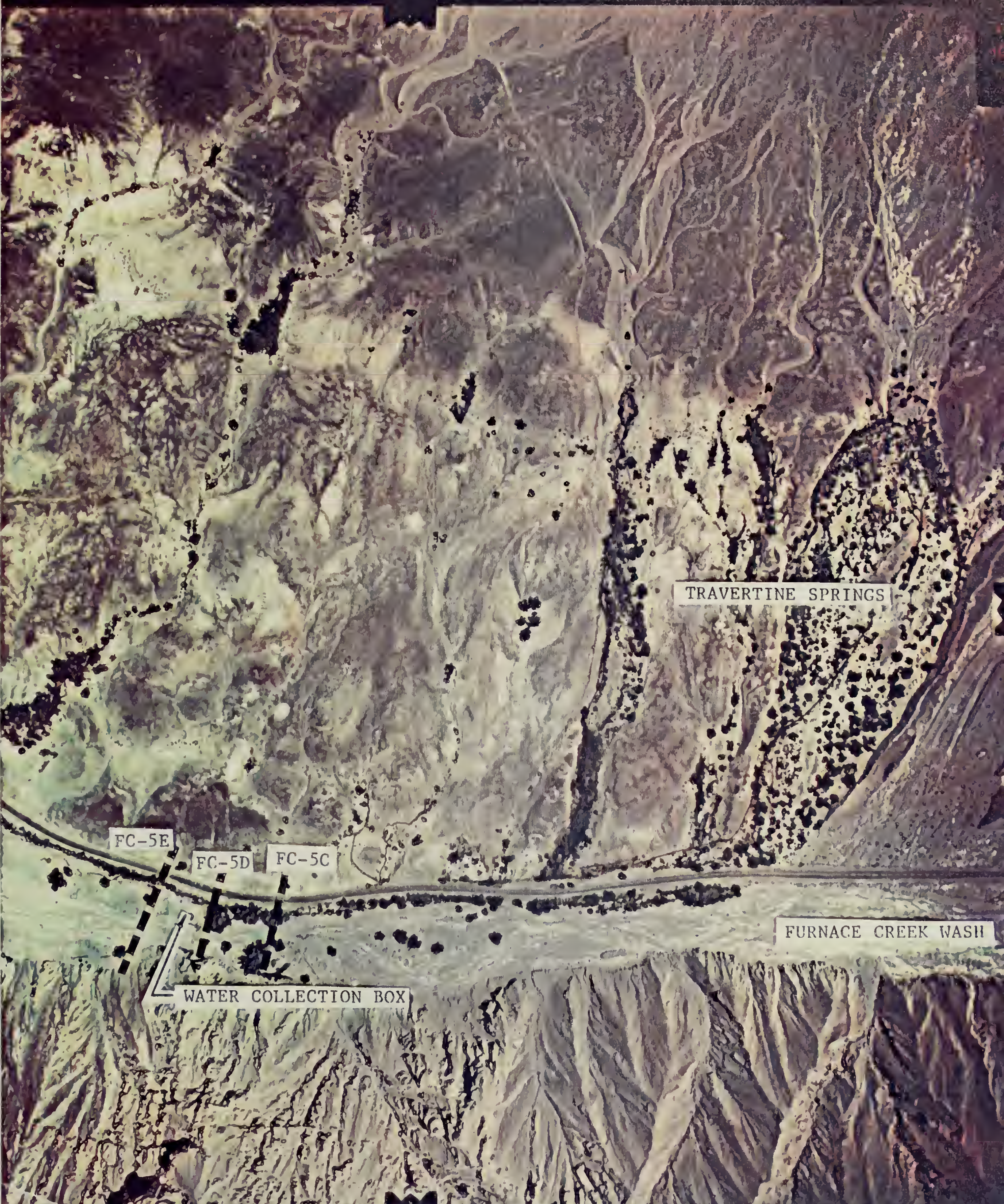
SECTION 5A

Q_{100} = Flow from FC-5 + FC-6 = 27,000 cfs

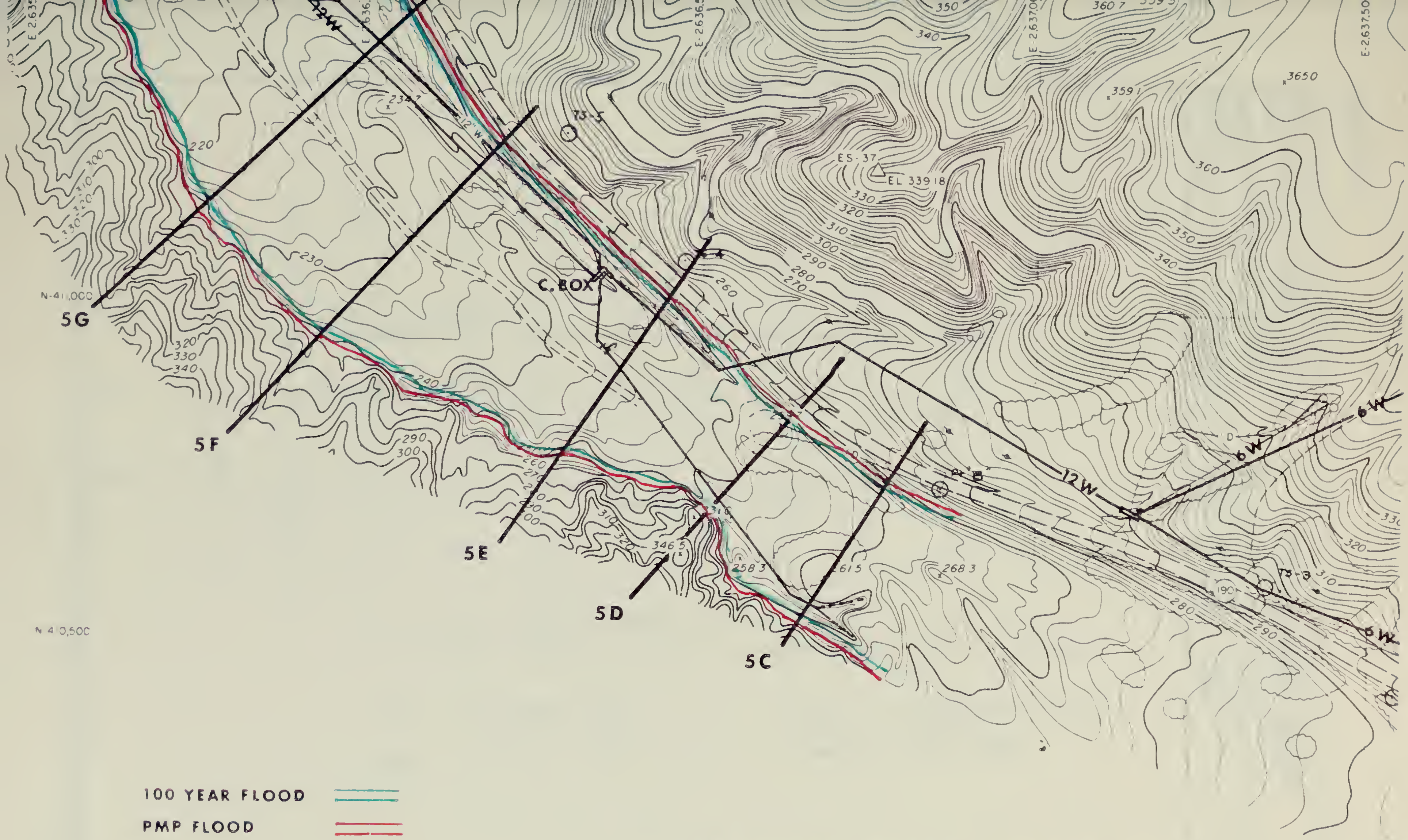
Q_{PM} = Flow from FC-5 + FC-6 = 90,000 cfs



SECTION 5B



FURNACE CREEK WATER COLLECTION AREA

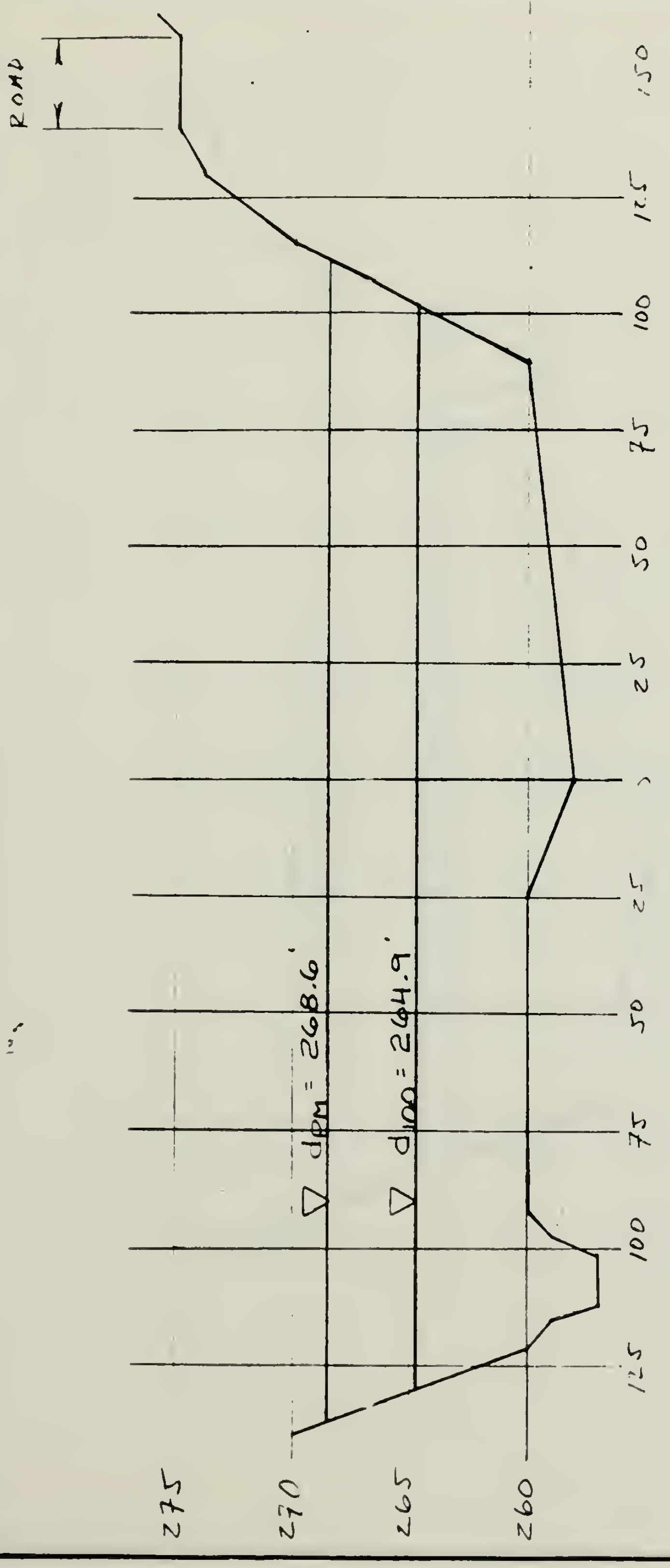


WATER INTAKE AREA - FURNACE CREEK

SCALE : 1" = 200'

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**			**Sheet** 29
Area WATER INTAKE				**of**
Project	**By** R. G.		**Checked**	**Pkg.**
Feature SECTION FC-5C	**Date** /27/84		**Date**	**Account**



SECTION 5C

Flow from FC-5 plus 10 year flow from FC-6

Q_{100} = 23,800 CFS

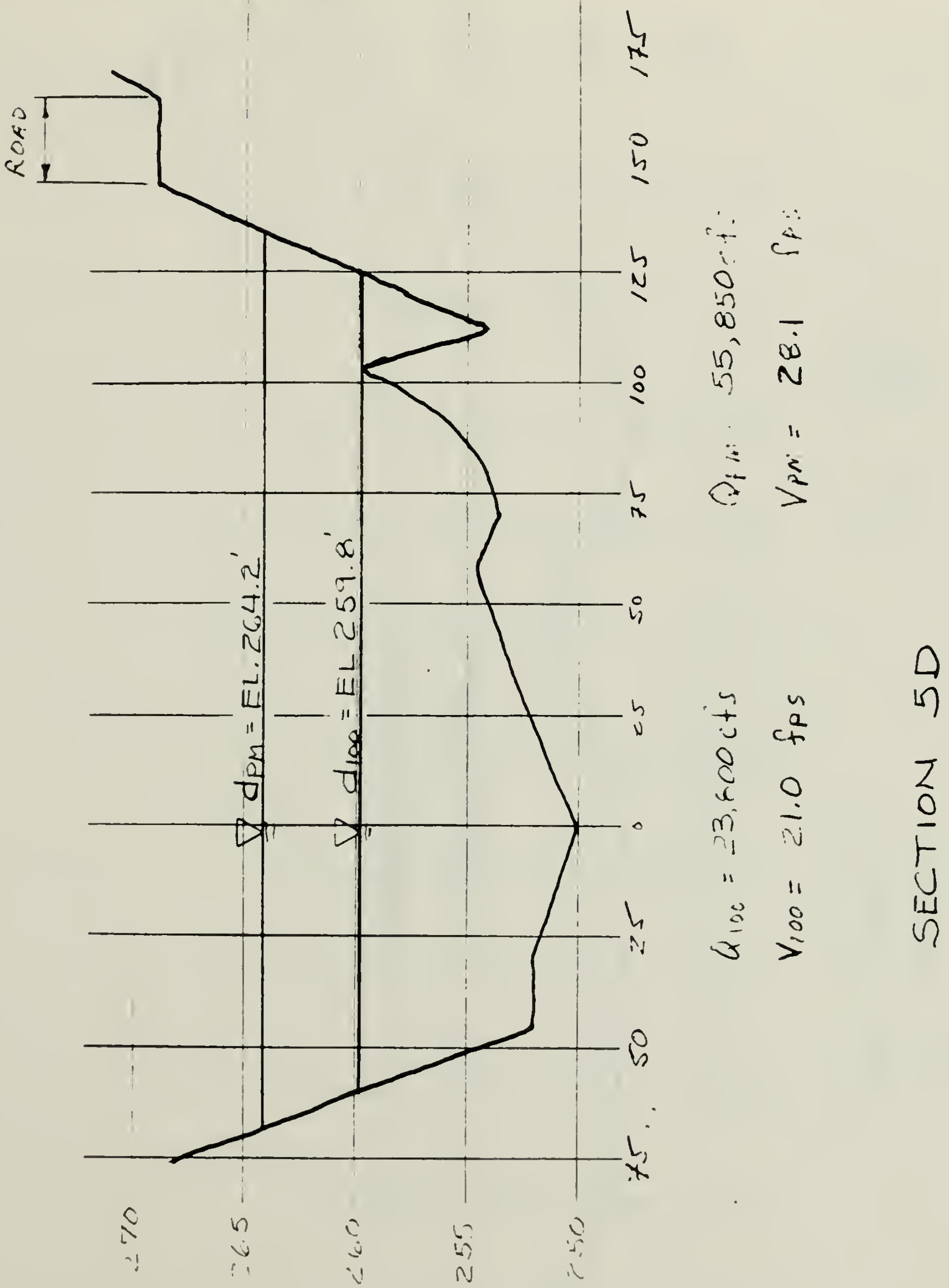
V_{100} = 19.2 FPS

Q_{PM} = 55,850 CFS

V_{100} = 26 FPS

FORM D S C - 44

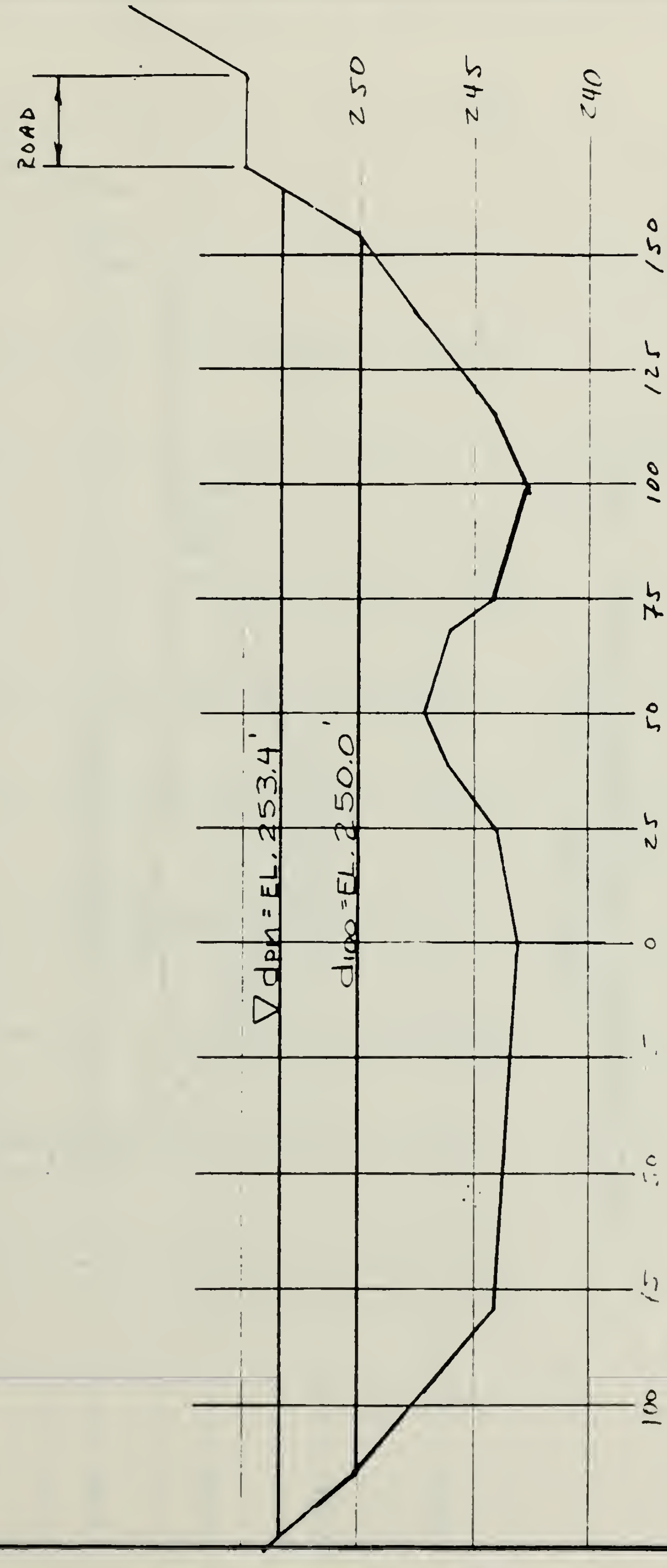
Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 30
Area WATER INTAKE			**of**
Project	**By** R G.	**Checked**	**Pkg.**
Feature SECTION FC-5D	**Date** 7/9/84	**Date**	**Account**



•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 31
Area WATER INTAKE		**of**
Project	**By** R.G. / **Checked**	**Pkg.**
Feature SECTION FC-5E	**Date** 6/29/84 / **Date**	**Account**



Q_{pm} = 55,850 cfs
V_{pm} = 24.2 fps

Q_{100} = 23,800 cfs
V_{100} = 17.6 fps

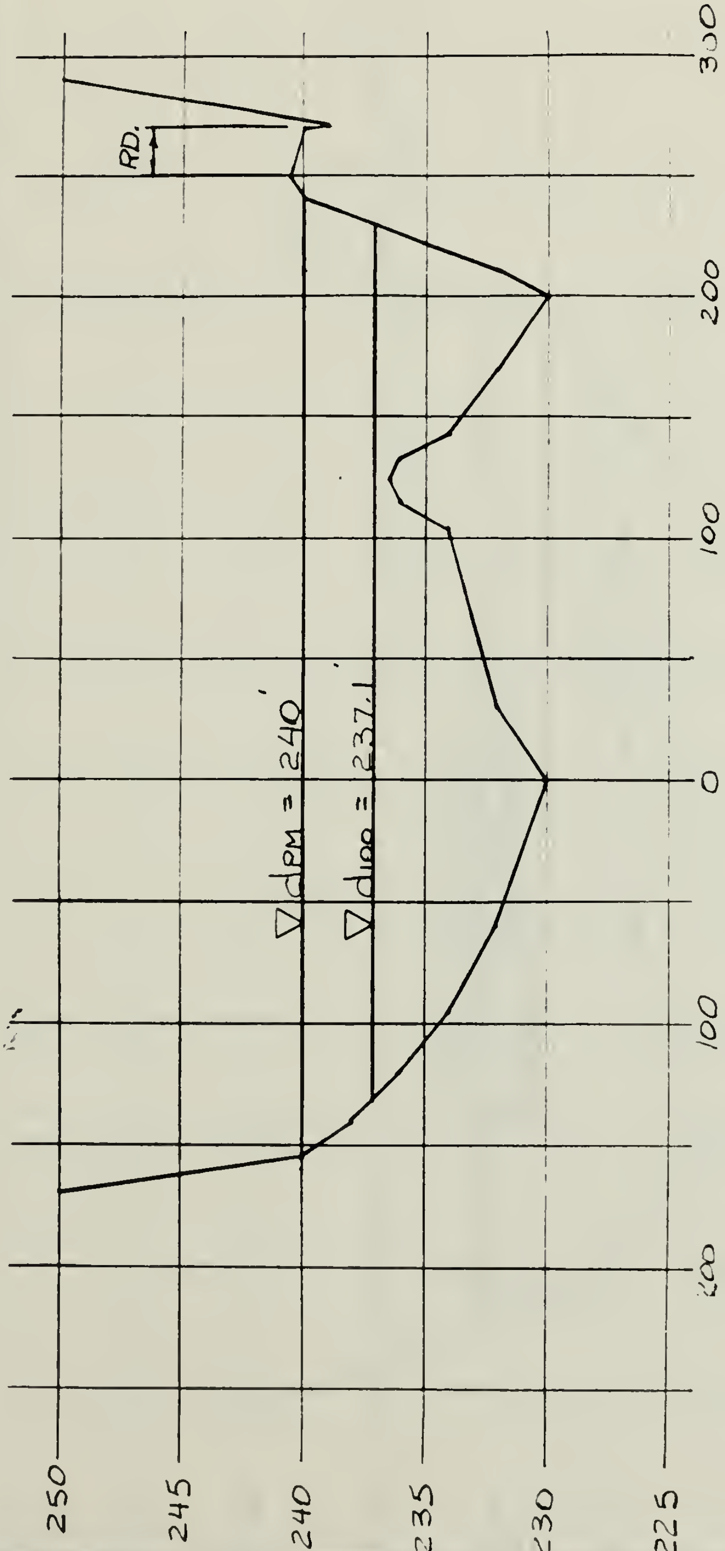
SECTION 5E

FC-5 plus 10-year from FC-6

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 32
Area			**of**
Project	**By**	**Checked**	**Pkg.**
Feature SECTION FC - 5F	**Date**	**Date**	**Account**



SECTION 5F

EC-5 plus 10-year from EC-6

Q_{100} = 23,800 CFS

V_{100} = 15.6 FPS

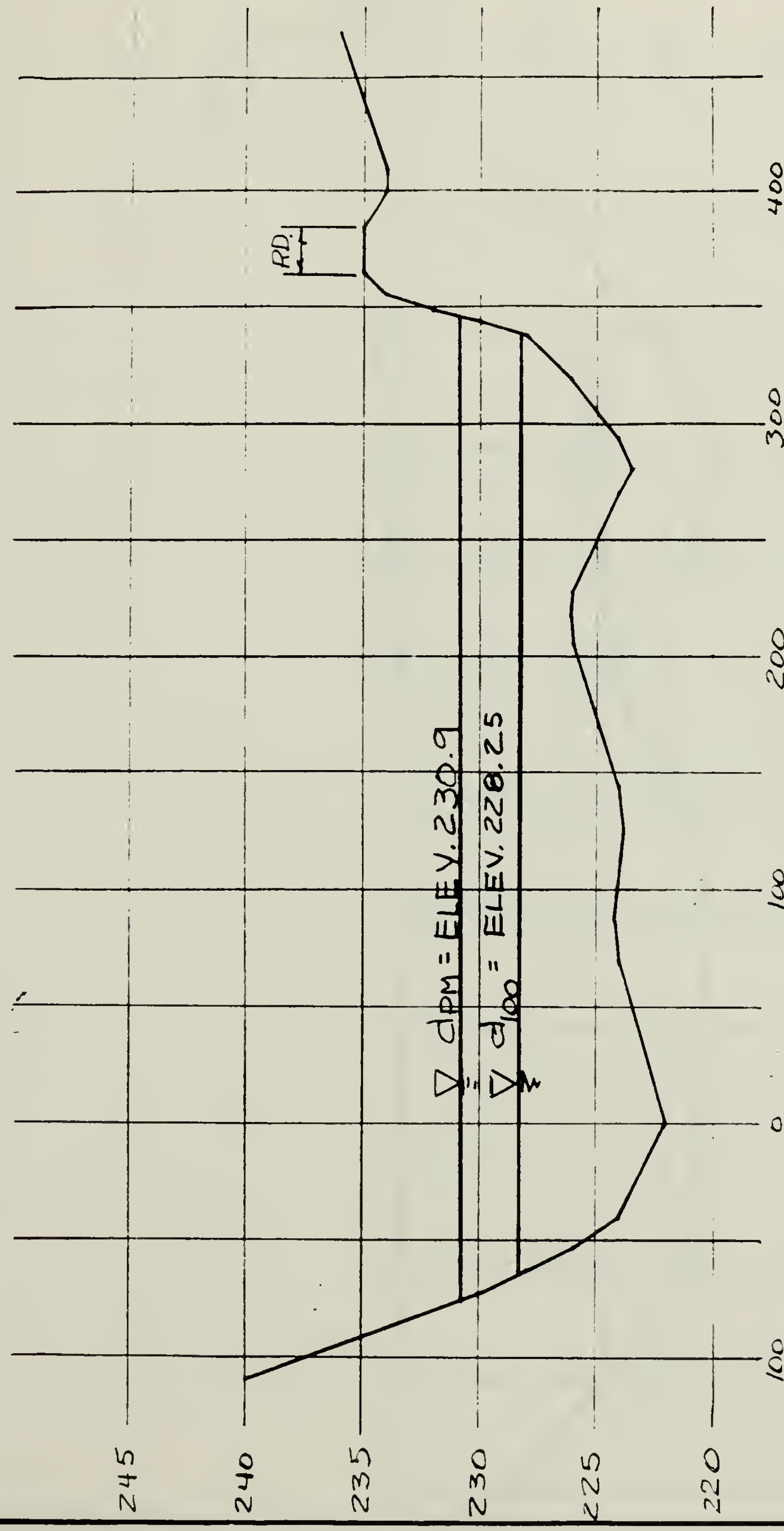
Q_{PM} = 55,850 CFS

V_{PM} = 21.22 FPS

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 33
Area WATER INTAKE			of
Project FURNACE CREEK	By	Checked	Pkg.
Feature SECTION FC-5G	Date	Date	Account



SECTION 5G

FC-5 plus 10 year from FC-6

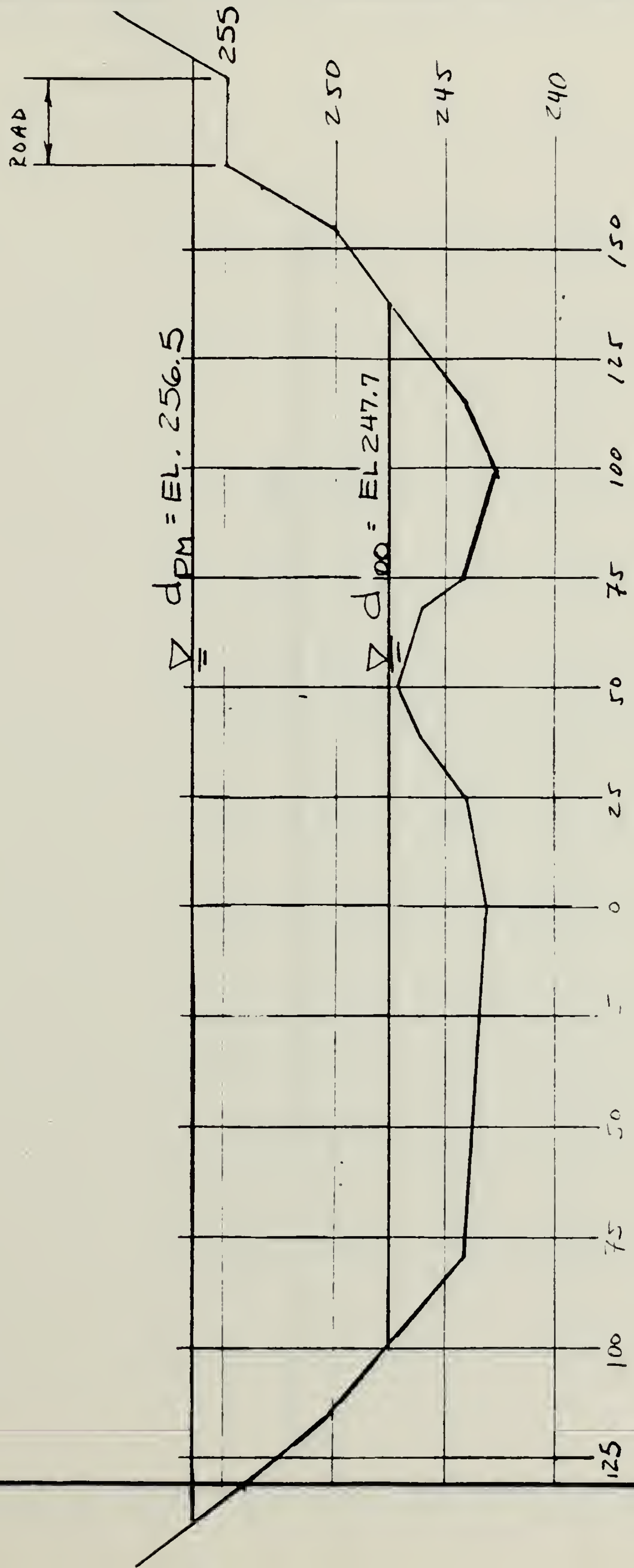
Q_{100} = 23,800
V_{100} =

Q_{PM} = 55,850
V_{PM} =

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 34
Area WATER INTAKE			of
Project	By R. G.	Checked	Pkg.
Feature SECTION FC-5E	Date 6/29/84	Date	Account



Q_{PM} = 90,000 CFS
V_{PM} = 27.0 FPS

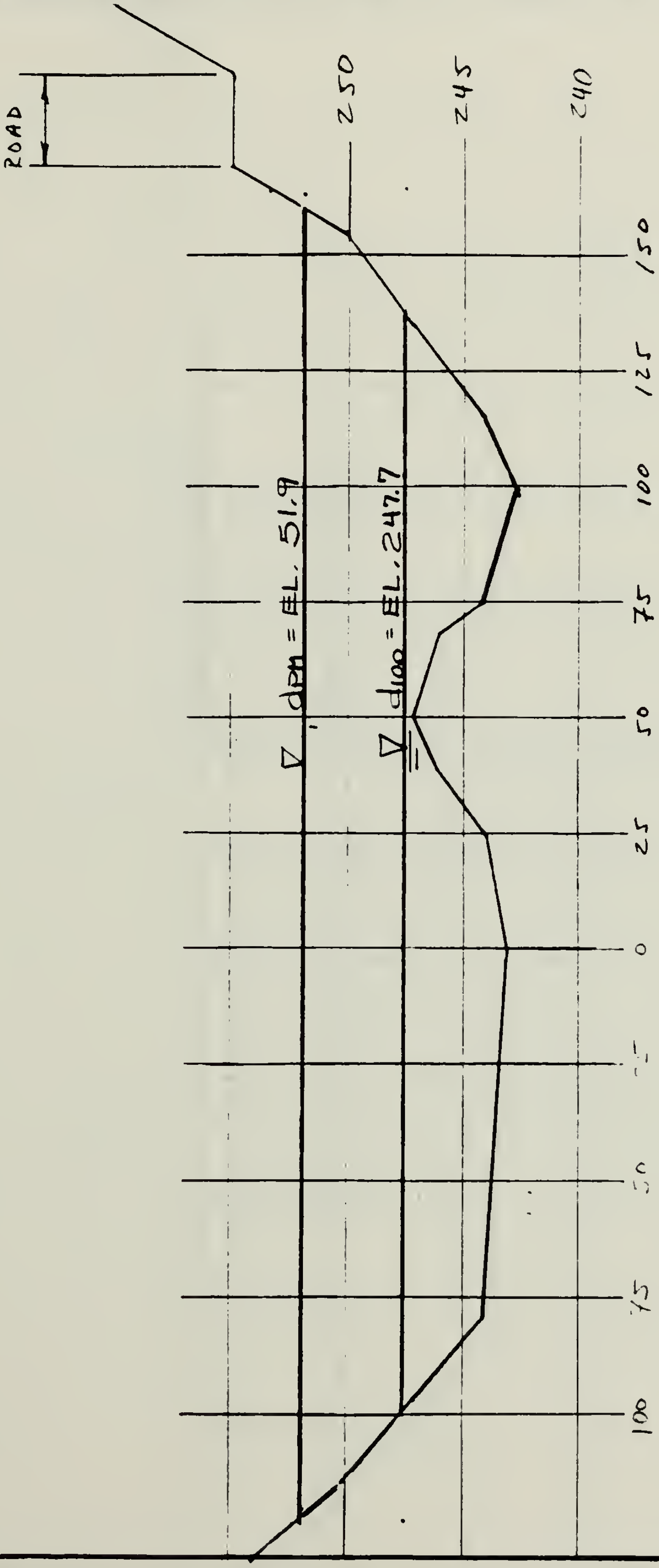
Q_{100} = 9,050 CFS
V_{100} = 11.7 FPS

SECTION 5E

FLOW AT EXISTING CONDITIONS

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 35
Area WATER INTAKE			of
Project	By P.G.	Checked	Pkg.
Feature SECTION FC-5E	Date 6/29/84	Date	Account



Q_{pm} = 41,100 CFS
V_{PM} = 21.5 FPS

Q_{100} = 9,050 CFS
V_{100} = 11.7 FPS

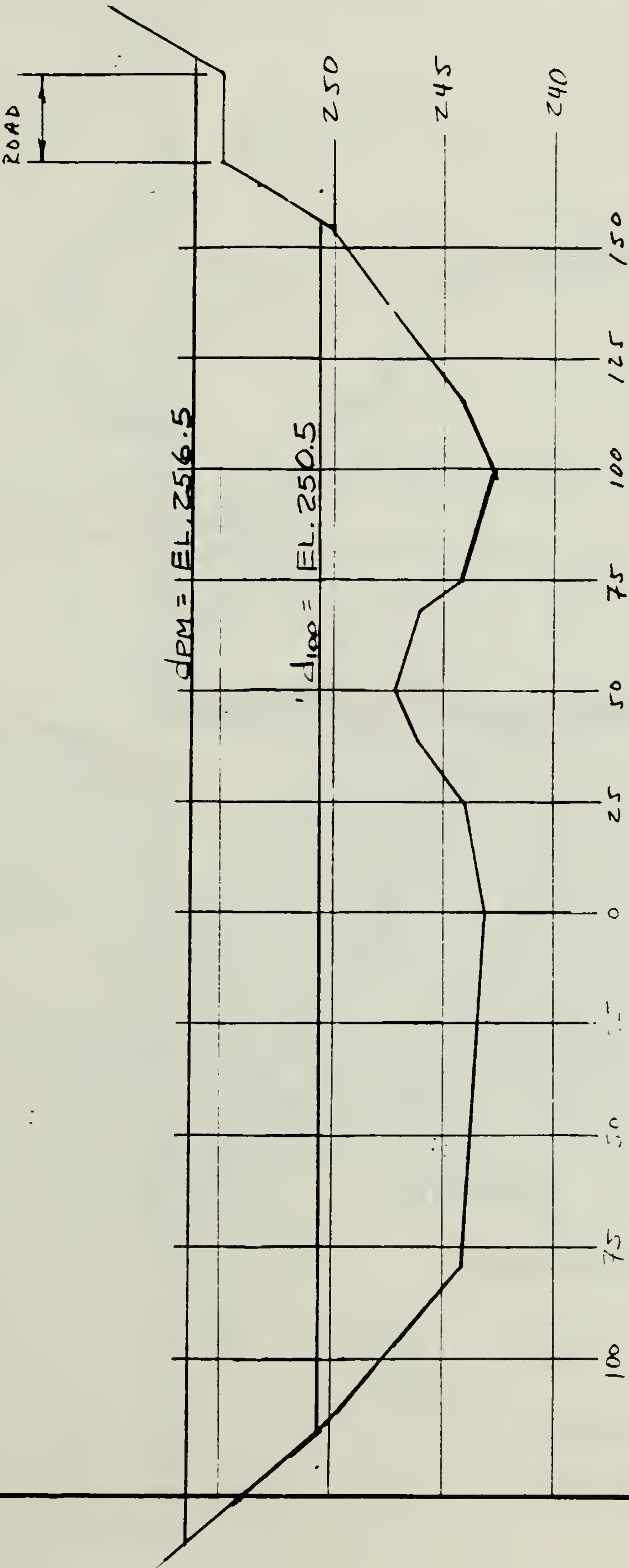
SECTION 5E

FLOW FROM FC-5 ONLY

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	Sheet 36
Area WATER INTAKE		of
Project	By R.G. / Checked	Pkg.
Feature SECTION FC-5E	Date 6/29/84 / Date	Account



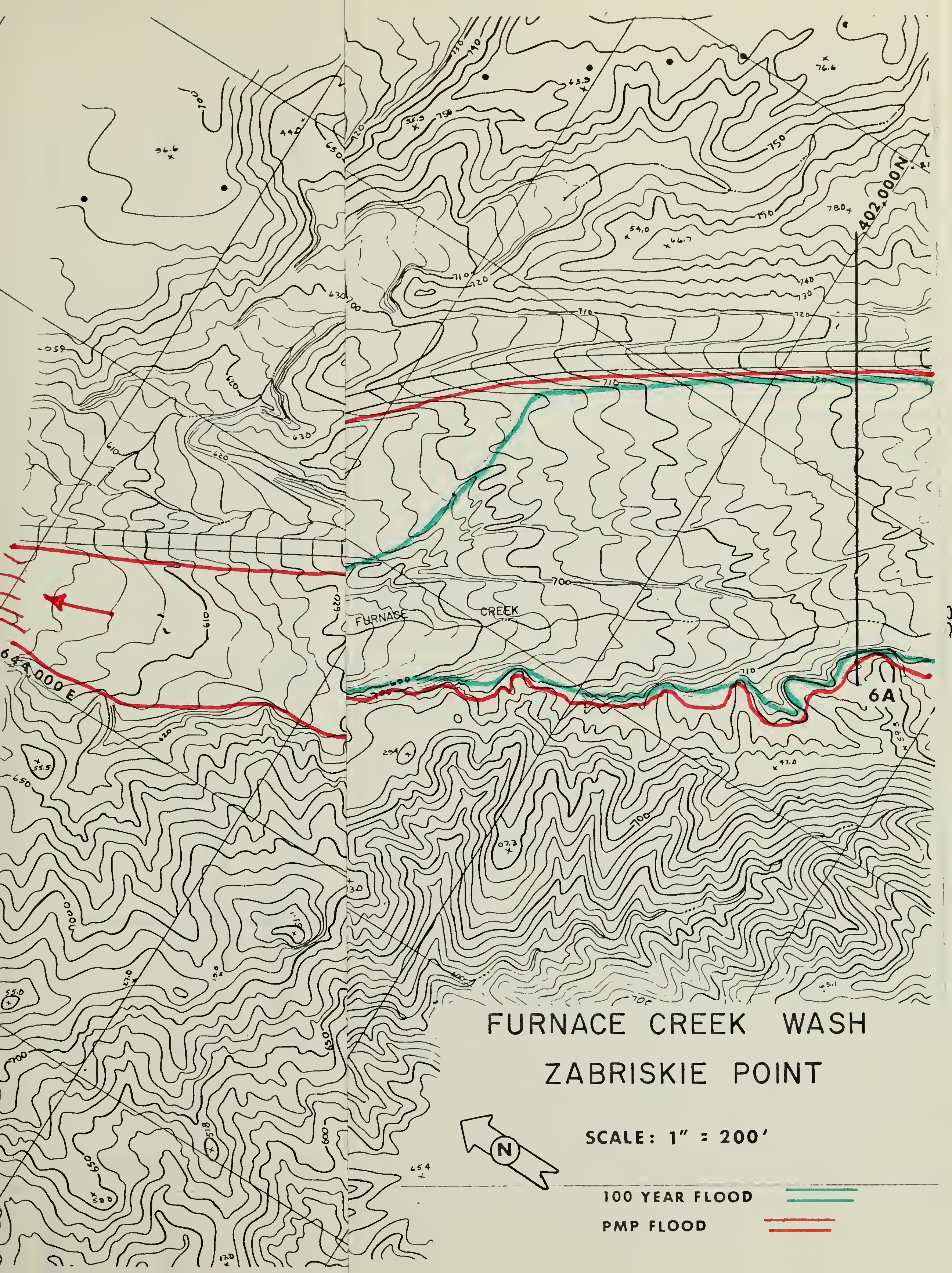
Q_{PM} = 90,000 CFS
V_{PM} = 27.0 fps

Q_{100} = 27,000 CFS
V_{100} = 18.5 fps

SECTION 5E

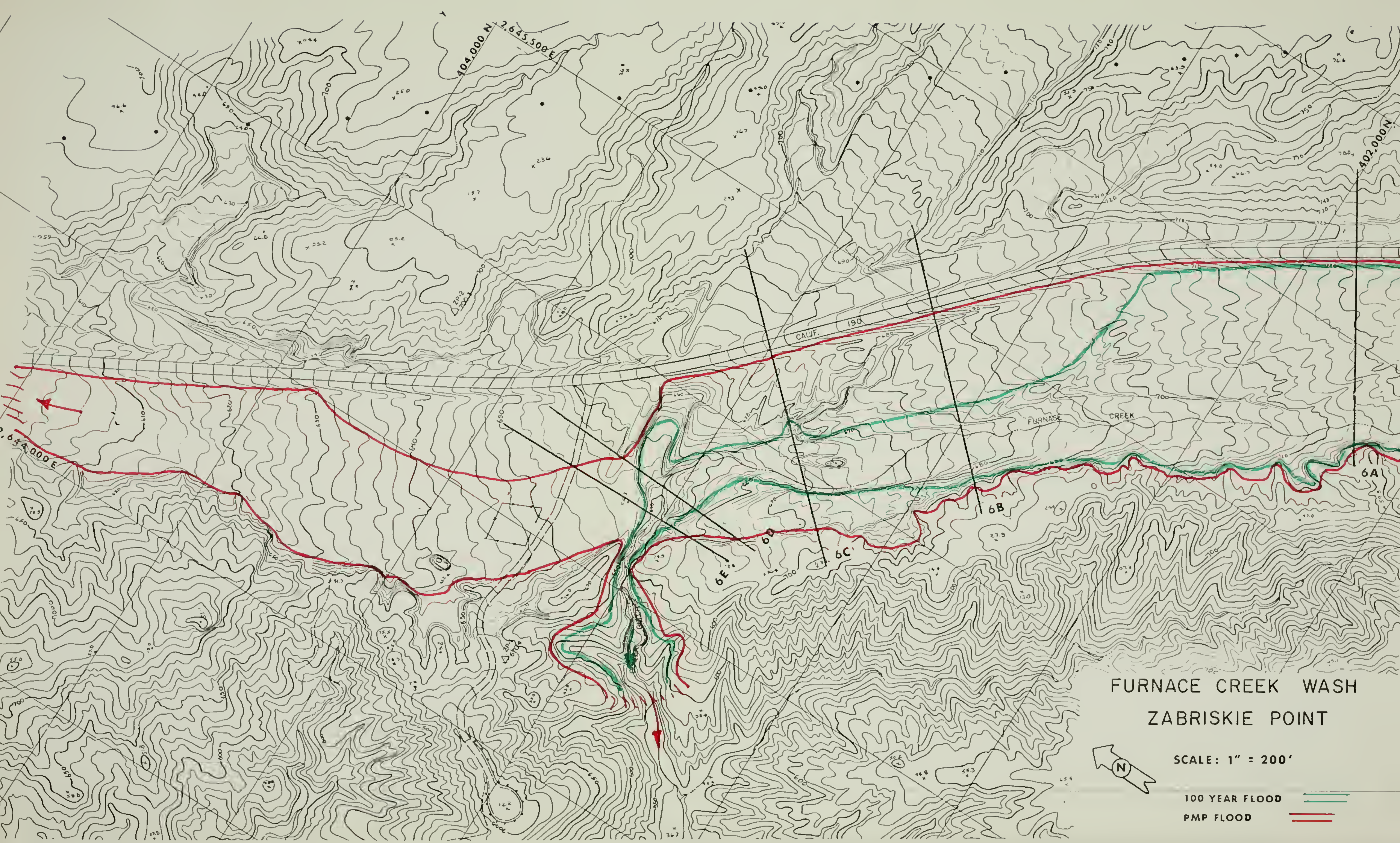
FLOW FROM FC-5 PLUS ALL FLOW FROM FC-6

•U.S. GPO: 1984-778-378



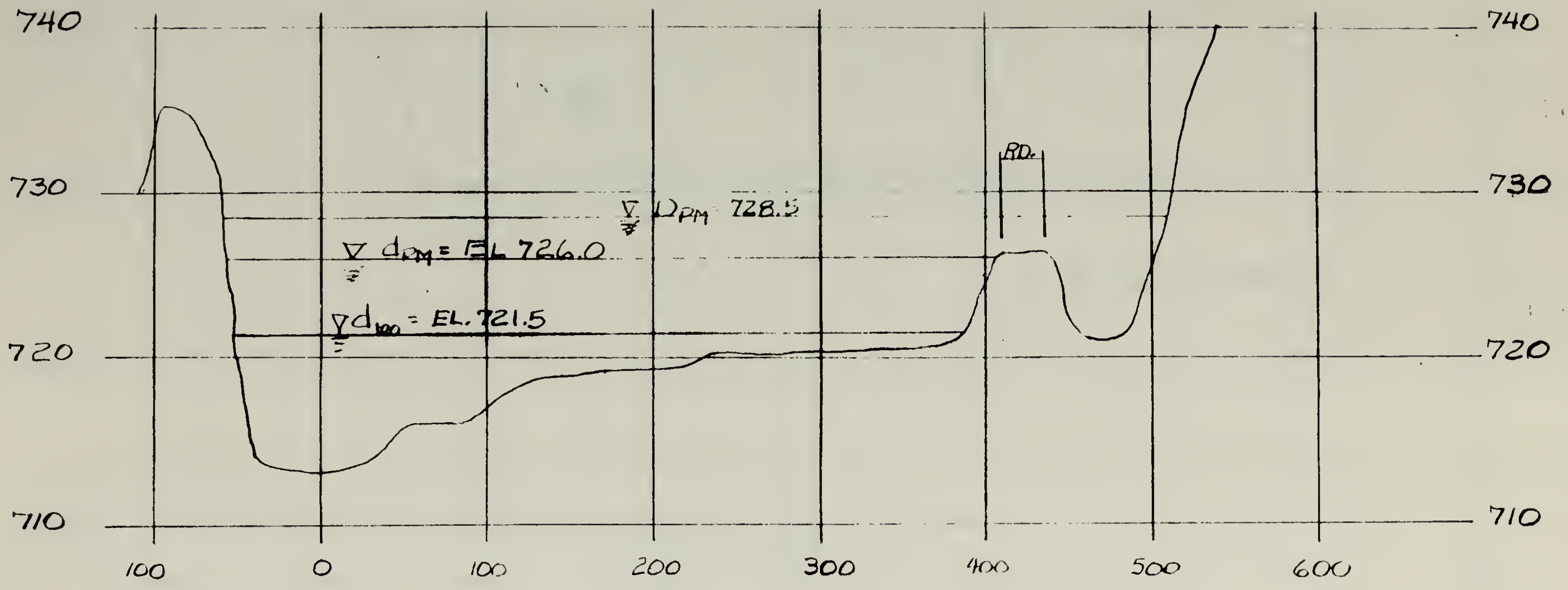
FURNACE CREEK WASH
ZABRISKIE POINT

SCALE: 1" = 200'



FURNACE CREEK WASH
ZABRISKIE POINT

SCALE: 1" = 200'



SECTION 6A (DOWNSTREAM)

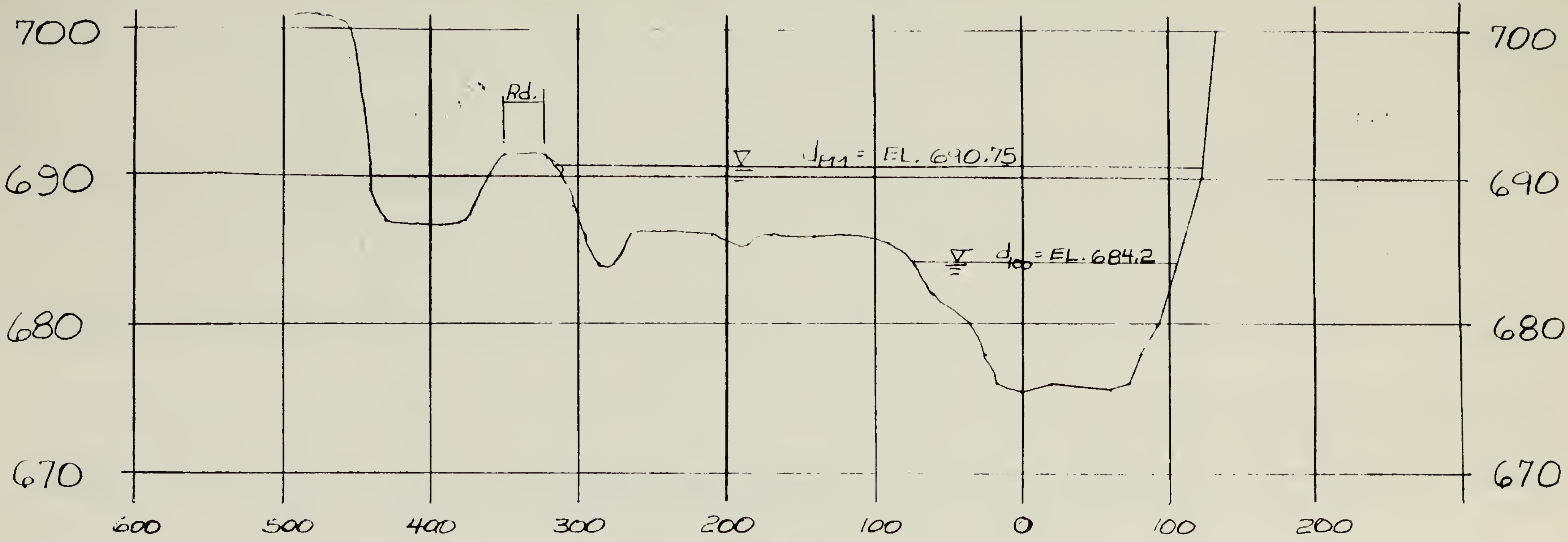
Q_{100} = 23,000 CFS

Q_{PM} = 89,200 CFS

S = 0.10

V_{100} = 15 FPS

V_{PM} = 25 FPS

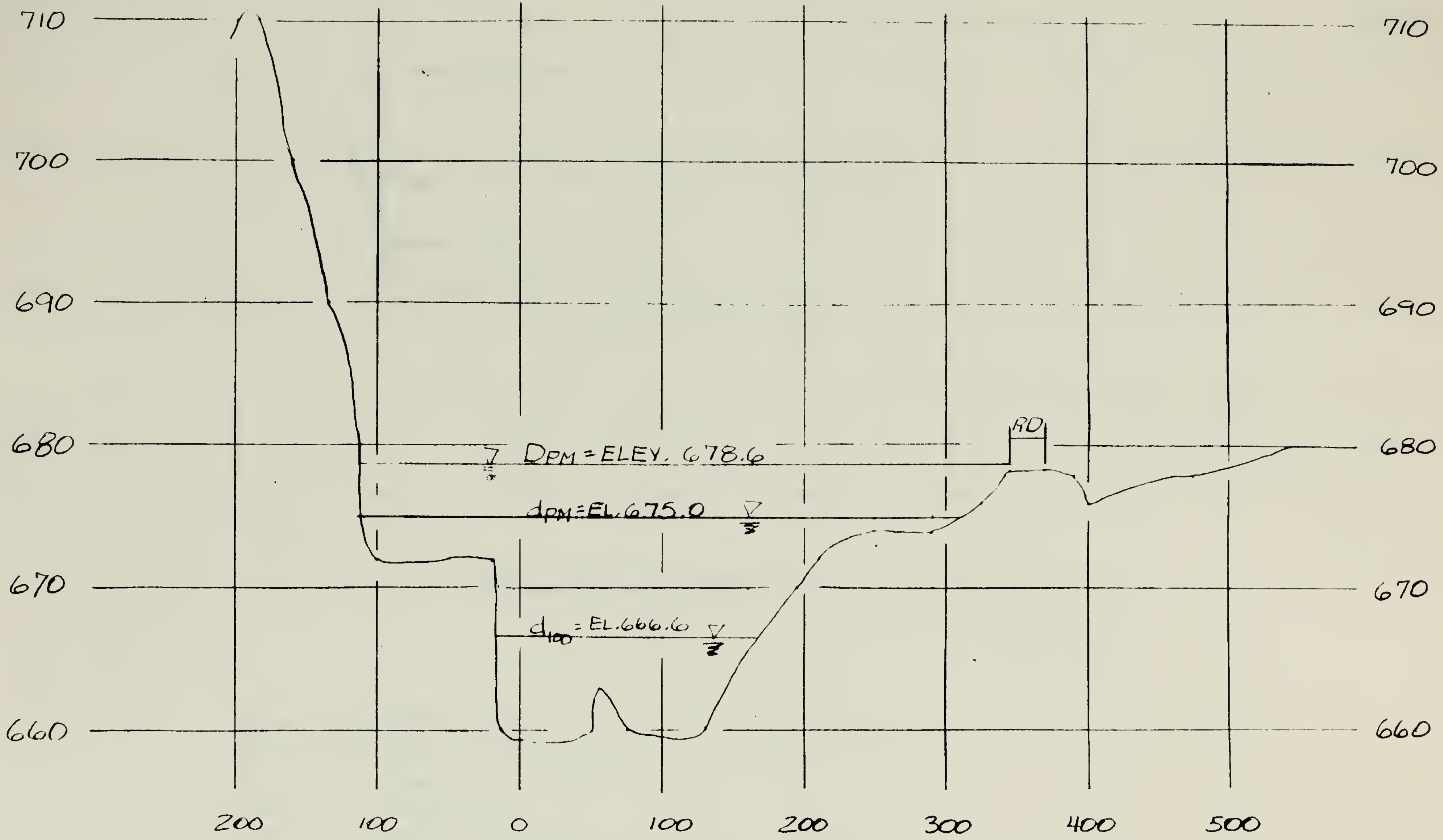


Q_{100} = 23,000 CFS
Q_{PM} = 89,200 CFS
S = 0.38
V_{100} = 21.5 FPS
V_{PM} = 25.5 FPS

$$\frac{Q}{A} = \frac{1.486}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}\text{; WHERE}$$

n = .045
S = .038 SLOPE
A = AREA
P = WETTED PERIMETER

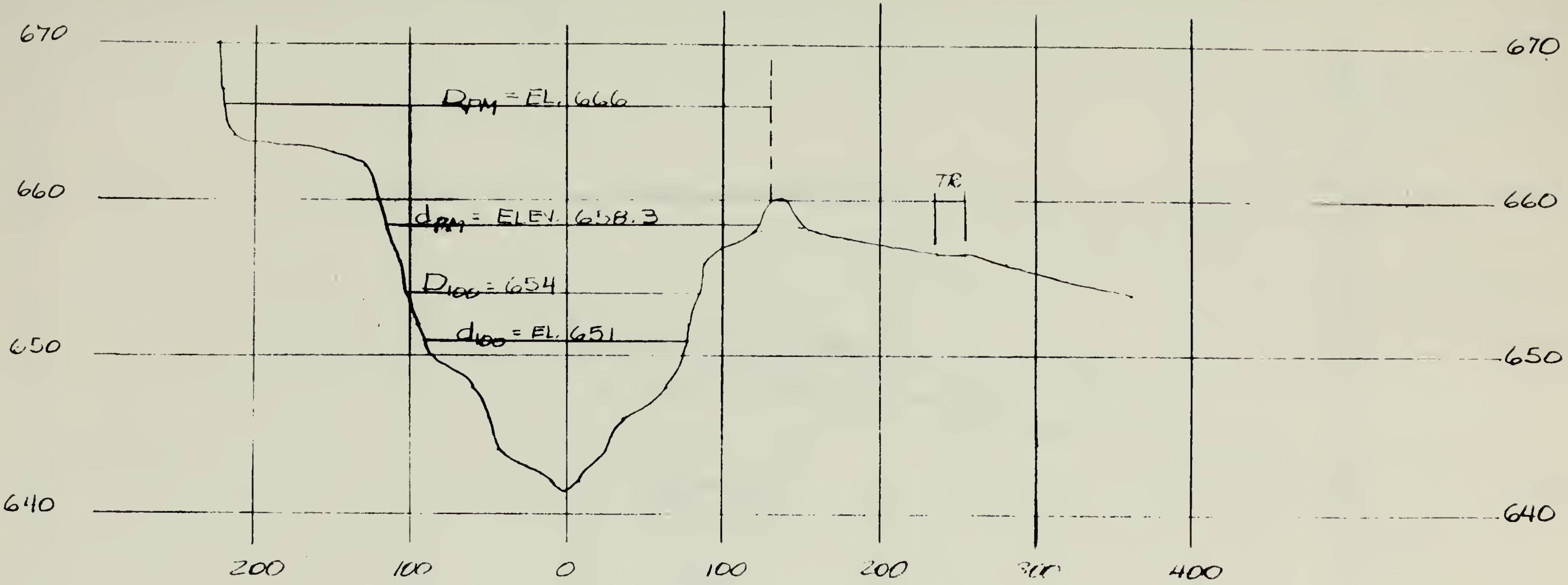
SECTION 6B (UPSTREAM)



SECTION FC-6C

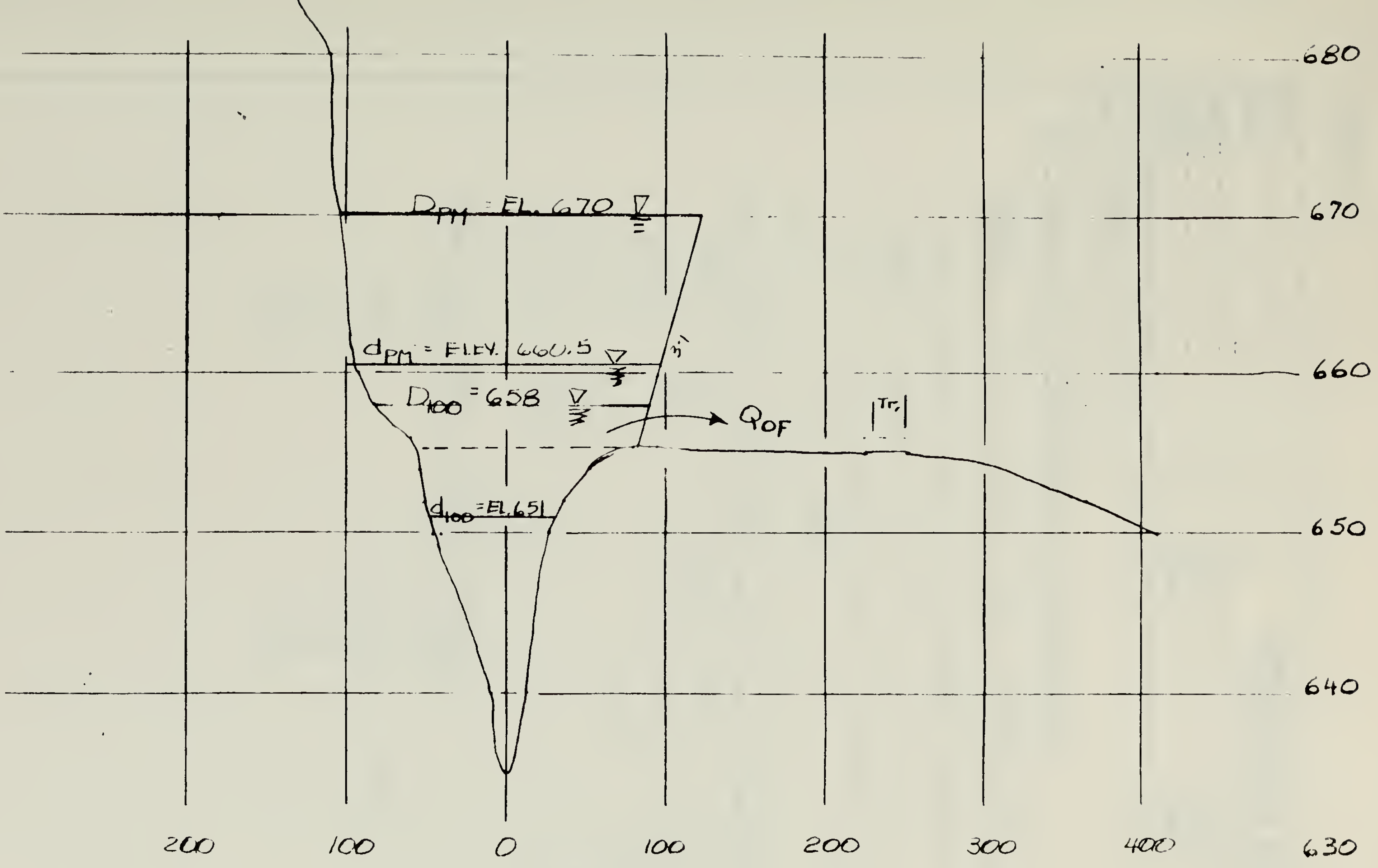
Q_{100} = 23,000
Q_{PM} = 89,200
S = 0.042

V_{100} = 21 FPS
V_{PM} = 27.5 FPS



SECTION FC-6D

Q_{100} = 23,000 CFS
Q_{PM} = 81,000 CFS
S = 0.061
V_{100} = 26.2 FPS
V_{PM} = 39.0 FPS



SECTION 6E

Q_{100} = 23,000 CFS
Q_{PM} = 89,200 CFS
S = 0.10
V_{100} = 37.5 FPS
V_{PM} = 47 FPS

$Q_{OVERFLOW}$ = 50,000 cfs

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 43
Area			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

I PRECIPITATION

A 100 YR. FREQUENCY (CON'T)

AREA FC-3 (FURNACE CREEK RANCH)

6 Hr., 100 Yr., POINT (116°47' Lgt.; 36°28' LAT.) = 1.7 = X_3

24 Hr., 100 YR., " " " = 3.0 = X_4

Y_{100} = 1 Hr., 100 YR., Point = $0.322 + 0.789 \left[\frac{X_3^2}{X_4} \right]$

= 1.08 in./HR.

FIND AMOUNTS FOR VARIOUS DURATIONS

100 yr. 15 min. = 0.57 (1.08) = 0.617 INCHES

100 yr. 30 min. = 0.79 (1.08) = 0.85 "

100 yr. 1 hr. = 1 (1.08) = 1.08 "

100 yr. 2 hr. = 1.23 "

100 yr. 3 hr. = 1.35 "

REDUCE FOR AREA SIZE

15 min.	0.617		
30 min.	0.85	x .922	0.78 INCHES
1 hr.	1.08	"	1.00 "
2 hr.	1.23		1.13 "
3 hr.	1.35	"	1.24 "

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 44
Area			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

I PRECIPITATION

A 100 YR. FREQUENCY (CONT)

AREA FC-5 (FURNACE CREEK RANCH

6 HR., 100 YR. POINT (116°43'W, 36° 29') = 1.9 IN. = X_3

24 HR., 100 YR. POINT " " = 3.4 IN = X_4

Y_{100} = 1 HR., 100 YR. POINT = $.322 + .789 \left[\frac{X_3^2}{X_4}\right]$ = 1.16

FIND AMOUNTS FOR VARIOUS DURATIONS

15 Min = 0.57 (1.16) = 0.66 IN.
30 Min = 0.79 (1.16) = 0.92 IN.
1 Hr. = 1 (1.16) = 1.16 IN.
2 Hr. = 1.37 IN.
3 Hr. = 1.53 IN.

REDUCE FOR SIZE (39.4 Sq. Miles)

30 Min. = 0.729 (.92) = 0.67 IN.
1 Hr. = .829 (1.16) = 0.96 IN.
2 hr. = .92 (1.37) = 1.26 IN.
3 hr. = .949 (1.53) = 1.45 IN.

FORM D S C - 44

Park	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 45
Area			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

II. PRECIPITATION:

A 100 YR. FREQUENCY (CON'T)

AREA EC-6, ZABRISKI POINT

6 Hr., POINT (116°40', 36°18'L) = 1.9 IN. = x_3

24 Hr., POINT " = 3.25 = x_4

Y_{100} = 1 Hr. POINT = $0.322 + .789\left[\frac{x_3^2}{x_4}\right]$. = 1.20 IN.

FIND AMOUNTS FOR VARIOUS DURATIONS

30 MIN. = 0.79 (1.20) = 0.95 IN.
1 Hr. = 1 (1.20) = 1.20 IN.
2 Hr. = = 1.36 IN.
3 Hr. = = 1.52 IN.
2 Hr. = = 2.52 IN.

REDUCE FOR SIZE (188.2 Miles²)

30 MIN. = 0.95 (0.565) = 0.54 IN.
1 Hr. = 1.20 (0.67) = 0.80 IN.
2 Hr. = 1.36 (0.75) = 1.20 IN.
3 Hr. = 1.52 (0.80) = 1.22 IN.
6 Hr. = 1.9 (0.855) = 1.62 IN.
12 hr. = 2.52 (0.885) 2.23 IN.

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 46
Area			**of**
Project	**By**	**Checked**	**Pkg.**
Feature	**Date**	**Date**	**Account**

II PRECIPITATION

B PROBABLE MAXIMUM PRECIPITATION (PMP)

1 AREA FC-2B (Cow Cr. School)

1 Hr., POINT = 6.5 IN.

RAINFALL FOR OTHER DURATIONS

15 MIN. = 0.48 (6.5) = 3.12
30 MIN. = 0.71 (6.5) = 4.62
45 MIN. = 0.88 (6.5) = 5.72
1 HR. = 1 (6.5) = 6.5
1½ HR. = 1.17 (6.5) = 7.6

No correction for area necessary.

2 AREA FC-3 (Furnace Cr. Ranch)

1 Hr., POINT = 6.5 IN. ; Reduce for Area = .86(6.5) = 5.6

RAINFALL FOR OTHER DURATIONS

30 MIN. = 0.71 (5.6) = 3.97
45 MIN = 0.88 (5.6) = 4.92
1 Hr = 1 (5.6) = 5.6
1½ Hr. = 1.17 (5.6) = 6.55
2 Hr. = 1.26 (5.6) = 7.06

3 AREA FC-5

1 Hr., POINT = 6.5 in; Reduce for Area = 6.5(.637) = 4.14

RAINFALL FOR OTHER DURATIONS

1 Hr. = 1 (4.14) = 4.14
1½ Hr. = 1.17 (4.14) = 4.84
2 Hr. = 1.26 (4.14) = 5.22
2½ Hr. = 1.315 (4.14) = 5.44
3 Hr. = 1.34 (4.14) = 5.55

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 47
Area			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

II PRECIPITATION:

B PMP (CON'T.)

4 AREA FC-6 : Zobriski Pt.

1 Hour, Point = 6.5 inches
Reduce for Area = 6.5(.475 @ 100 Sq. Miles) = 3.09

RAINFALL FOR OTHER DURATIONS

1 Hr. = 1 (3.09) = 3.09
1½ Hr. = 1.17 (3.09) = 3.62
2 Hr. = 1.26 (3.09) = 3.89
2½ Hr. = 1.315 (3.09) = 4.06
3 Hr. = 1.34 (3.09) = 4.14

C GENERAL-TYPE MAXIMUM STORM FOR FC6

6 Hr., POINT = 3 INCHES
REDUCE FOR AREA OF 168 Mi² = .82 (3) = 2.46 INCHES

RAINFALL FOR OTHER DURATIONS

3 Hrs. = .63 (2.46) = 1.55
4 Hrs. = .77 (2.46) = 1.89
5 Hrs. = .88 (2.46) = 2.16
6 hrs. = 1 (2.46) = 2.46
8 hrs. = 1.18 (2.46) = 2.90
10 hrs. = 1.36 (2.46) = 3.35
12 hrs. = 1.53 (2.46) = 3.76
14 hrs. = 1.66 (2.46) = 4.08

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY	NATIONAL PARK SERVICE DENVER SERVICE CENTER			Sheet 48
Area FURNACE CREEK				of
Project	By REB		Checked	Pkg.
Feature	Date 5/24/84		Date	Account

II PRECIPITATION

D 10 YEAR FREQUENCY FOR FC6

First Determine 2 Year - 1 hour:

6 Hr., 2 Year, Point (116°40', 36°18'L) = 0.9 in. = X_1
24 Hr., 2 Year, Point (116°40', 36°18L) = 1.3 in. = X_2
From NOAA ATLAS 2:
Y_2 = 1 hr. point 2 Yr. freq. = $.005 + .852 \left(\frac{X_1^2}{X_2}\right) = 0.53$

From NOAA ATLAS 2, Volume XI, Figure 6:
Plot Y_2 = 0.53 and Y_{100} = 1.20
Y_{10} = 0.80

FIND AMOUNTS FOR VARIOUS DURATIONS

Table 12:
30 Min. = 0.79(0.80) = 0.63 in.
Figure 15: (10 hr., 6 hr. = 1.25)
1 Hr. = Y_{10} = 0.80
2 Hr. = = 0.97
3 Hr. = = 1.06
6 Hr. = = 1.25
Figure 16:
12 Hr. = = 1.88
24 Hr. = = 2.2

ADJUST FOR AREA (138 Sq. Mi) (NOAA ATLAS 2, Fig. 14)

30 Min. = (0.57) .63 = 0.36
1 hr. = 0.8 (0.8) = 0.64
2 hr = 0.75 (0.97) = 0.73
3 hr. = 0.8 (1.06) = 0.85
6 hr = 0.86 (1.25) = 1.08
12 hr. = 0.89 (1.88) = 1.67
24 hr. = 0.92 (2.2) = 2.02

FORM D S C - 44

Park	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 49
Area			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

II PRECIPITATION

E 5 YEAR FREQUENCY FOR FC6

First Determine 2year - 1hour.
From D above: $Y_2 = 0.53$

From NOAA ATLAS 2, Volume XI, Figure 6:
Plot $Y_2 = .53$; and $Y_{100} = 1.20$
$Y_5 =$

Note 2 Yr. = 5,300 cfs

•U.S. GPO: 1984-778-378

FORM DSC-44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 50
Area FURNACE CREEK		**of**
Project	**By** R.G. / **Checked**	**Pkg.**
Feature	**Date** 6/1/34 / **Date**	**Account**

III RUNOFF FOR FC-3

A 100 YR. FLOOD

$T_c = 1.03 \quad A = 6.05$

ASSUME MOUNTAINS RETAIN .1" RAIN

DURATION = 30 min.

$T_P = \frac{.5}{2} + .6(1.03) = .87$

$Q_P = \frac{484(6.05)(.78 - .10)}{.87} = 2289$ cfs.

DURATION = 1 HR.

$T_P = \frac{1.0}{2} + .6(1.03) = 1.12$

$Q_P = \frac{484(6.05)(1.00 - .10)}{1.12} = 2353$ cfs.

DURATION = 2 HR.

$T_P = \frac{2.0}{2} + .6(1.03) = 1.62$

$Q_P = \frac{484(6.05)(1.13 - .10)}{162} = 1862$ cfs.

RATIONAL METHOD (1 HR)

$Q_P = (1.00)\left(\frac{1.00}{1.0}\right) 640(6.05) = 3872$ cfs.

WAANANEN AND CRIPPEN

$Q_P = 1080 A^{.71} = 1080(6.05)^{.71} = 3877$ cfs.

USE 2400 cfs

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 51
Area FURNACE CREEK			**of**
Project	**By** R. G.	**Checked**	**Pkg.**
Feature	**Date** 6/1/84	**Date**	**Account**

III RUNOFF FOR FC-5

A 100 YR. FLOOD

$T_c = 2.42 \quad A = 39.4$

DURATION = 1 HR

$T_p = \frac{1.0}{2} + .6(2.42) = 1.95$

$$Q_p = \frac{484(39.4)(.96-.10)}{1.95} = 8410 \text{ cfs.}$$

DURATION = 2 HR.

$T_p = \frac{2.0}{2} + .6(2.42) = 2.45$

$$Q_p = \frac{484(39.4)(1.26-.10)}{2.45} = 9029 \text{ cfs.}$$

DURATION = 3 HR.

$T_p = \frac{3.0}{2} + .6(2.42) = 2.95$

$$Q_p = \frac{484(39.4)(1.45-.10)}{2.95} = 8727 \text{ cfs.}$$

RATIONAL METHOD (2 HRS)

$Q_p = 1.00\left(\frac{1.26}{2}\right)640(39.4) = 15,886 \text{ cfs.}$

WAANANEN AND CRIPPEN

$Q_p = 1030(39.4)^{.71} = 14,663 \text{ cfs.}$

USE 7050 cfs

FORM DSC-44

Park DEATH VALLEY N.M.		**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 52
Area				**of**
Project		**By** E.G.	**Checked**	**Pkg.**
Feature		**Date** 5/1/84	**Date**	**Account**

III RUNOFF FOR FC-6

$\boxed{A}$ 100 YR. FLOOD

$T_c = 5.22$ HRS. $A = 188.17$ mi^2

DURATION = 3 HRS.

$T_p = \frac{3.0}{2} + .6(5.22) = 4.63$

$Q_p = \frac{484(188.17)(1.22-.1)}{4.63} = 22{,}030$ cfs.

DURATION = 6 HRS.

$T_p = \frac{6.0}{2} + .6(5.22) = 6.13$

$Q_p = \frac{484(188.17)(1.62-.1)}{6.13} = 22{,}583$ cfs

DURATION = 12 HRS.

$T_p = \frac{12.0}{2} + .6(5.22) = 9.13$

$Q_p = \frac{484(188.17)(2.23-.1)}{9.13} = 21{,}247$ cfs.

RATIONAL METHOD (6 HRS) $Q = 1.00\left(\frac{1.62}{6}\right)640(188.17) = 32{,}516$ cfs.

WHAANANEN AND CRIPPEN

$Q = 1080(188.17)^{.7} = 44{,}500$ cfs.

USE 23,000 cfs.

FORM DSC - 44

Park DEATH VALLEY N.M	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 53
Area FURNACE CREEK			**of**
Project	**By** R.G.	**Checked**	**Pkg.**
Feature	**Date** 6/1/84	**Date**	**Account**

III | RUNOFF FOR FC-3

B PMP FLOOD

$T_c = 1.03$ HR. $A = 6.05$

ASSUME MOUNTAINS RETAIN .1" OF RAINFALL

DURATION = 30 MIN.

$$T_P = \frac{.5}{2} + .6(1.03) = .87$$

$$Q_P = \frac{484(6.05)(3.97-.1)}{.87} = 13,025 \text{ cfs.}$$

DURATION = 45 MIN.

$$T_P = \frac{.75}{2} + .6(1.03) = .99$$

$$Q_P = \frac{484(6.05)(4.92-.1)}{.99} = 14,256 \text{ cfs.}$$

DURATION = 1 HR.

$$T_P = \frac{1.0}{2} + .6(1.03) = 1.12$$

$$Q_P = \frac{484(6.05)(5.6-.1)}{1.12} = 14,330 \text{ cfs}$$

DURATION = 1.5 HRS.

$$T_P = \frac{1.5}{2} + .6(1.03) = 1.37$$

$$Q_P = \frac{484(6.05)(6.55-.1)}{1.37} = 13,786 \text{ cfs.}$$

RATIONAL METHOD (1 HRS) $Q_P = 1.00\left(\frac{5.6}{1}\right)(640)(6.05) = 21,683$ cfs.

WAANANEN AND CRIPPEN $Q_P = 13900(6.05)^{.029}(6.05^{.5}+5)^{-1.341}$

$= 42,590$ cfs.

MATTHAI $Q = 11,000(6.05)^{.61} = 32,981$ cfs.

USE 14,400 cfs.

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 54
Area FURNACE CREEK			**of**
Project	**By** Z. G.	**Checked**	**Pkg.**
Feature	**Date** 6/1/84	**Date**	**Account**

III ZUNOFF FOR FC-5

$\boxed{5}$ PMP FLOOD

$T_c = 2.42 \quad A = 39.4$

DURATION = 1.5 HRS.

$T_p = \frac{1.5}{2} + .6(2.42) = 2.20$

$Q_p = \frac{484(39.4)(4.84-.1)}{2.20} = 41{,}086$ cfs.

DURATION = 2 HRS.

$T_p = \frac{2.0}{2} + .6(2.42) = 2.45$

$Q_p = \frac{484(39.4)(5.22-.1)}{2.45} = 39{,}852$ cfs.

TRY DURATION = 1 HR.

$T_p = \frac{1.0}{2} + .6(2.42) = 1.95$

$Q_p = \frac{484(39.4)(4.14-.1)}{1.95} = 39{,}508$

RATIONAL METHOD (1.5 HRS.)

$Q_p = 1.00\left(\frac{5.55}{3}\right)640(39.4) = 46{,}650$

WAANANEN AND CRIPPEN

$Q_p = 28000(39.4)^{1.027}(39.4^{.5}+5)^{-1.341} = 168{,}257$ cfs.

MATHAI $Q_p = 11{,}000(39.4)^{.61} = 103{,}430$ cfs.

USE 41,100 cfs.

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 55 **of**
Area FURNACE CREEK		
Project	**By** R. G. **Checked**	**Pkg.**
Feature	**Date** 6/1/84 **Date**	**Account**

III RUNOFF FOR FC-6

B PMP FLOOD

$T_c = 1.93$ HRS, $A = 100\ mi^2$

DURATION = 1.5 HRS.

$$T_p = \frac{1.5}{2} + .6(1.93) = 1.91$$

$$Q_p = \frac{484(100.0)(3.62-.1)}{1.91} = 89,198 \text{ cfs.}$$

DURATION = 2 HRS.

$$T_p = \frac{2.0}{2} + .6(1.93) = 2.16$$

$$Q_p = \frac{484(100.0)(3.89-.1)}{2.16} = 84,924 \text{ cfs.}$$

TRY DURATION = 1 HR.

$$T_p = \frac{1.0}{2} + .6(1.93) = 1.66$$

$$Q_p = \frac{484(100.0)(3.09-.1)}{1.66} = 87,178 \text{ cfs.}$$

RATIONAL METHOD (2 HRS)

$$Q_p = 1.00\left(\frac{3.89}{2}\right)640(100.0) = 124,480 \text{ cfs.}$$

WAANANEN AND CRIPPEN

$$Q_p = 98900(100.0^{1.027})(100.0^{.5}+5)^{-1.341}$$

$$= 299,266 \text{ cfs.}$$

MATTHAI

$$Q_p = 11,000(100.0)^{.61} = 182,555 \text{ cfs.}$$

USE 89,200 cfs.

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 56
Area FURNACE CREEK		**of**
Project	**By** [illegible] **Checked**	**Pkg.**
Feature	**Date** 3/1/84 **Date**	**Account**

III RUNOFF FOR FC-6

C GENERAL TYPE MAXIMUM STORM

$T_c = 5.22 \quad A = 188.17$

DURATION = 4 HRS.

$T_p = \frac{4.0}{2} + .6(5.22) = 5.13$

$Q_p = \frac{484(188.17)(1.89-.1)}{5.13} = 31,778$ cfs.

DURATION = 5 HRS.

$T_p = \frac{5.0}{2} + .6(5.22) = 5.63$

$Q_p = \frac{484(188.17)(2.16-.1)}{5.63} = 33,323$ cfs.

DURATION = 6 HRS.

$T_p = \frac{6.0}{2} + .6(5.22) = 6.13$

$Q_p = \frac{484(188.17)(2.46-.1)}{6.13} = 35,063$ cfs.

DURATION = 8 HRS.

$T_p = \frac{8.0}{2} + .6(5.22) = 7.13$

$Q_p = \frac{484(188.17)(2.90-.1)}{7.13} = 35,765$ cfs.

DURATION = 10 HRS.

$T_p = \frac{10.0}{2} + .6(5.22) = 8.13$

$Q_p = \frac{484(188.17)(3.35-.1)}{8.13} = 36,407$ cfs.

DURATION = 12 HRS.

$T_p = \frac{12.0}{2} + .6(5.22) = 9.13$

$Q_p = \frac{484(188.17)(3.76-.1)}{9.13} = 36,510$ cfs.

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 57
Area FURNACE CREEK			of
Project	By R.G.	Checked	Pkg.
Feature	Date 5/1/84	Date	Account

III RUNOFF FOR FC-6

C GENERAL TYPE MAXIMUM STORM (CONT.)

DURATION = 14 HRS.

$T_p = \frac{14.0}{2} + .6(5.22) = 10.13$

$Q_p = \frac{484(188.17)(4.08-.1)}{10.13} = 35,782$ cfs.

RATIONAL METHOD (12 HRS.)

$Q_p = 1.00\left(\frac{3.76}{12}\right)640(188.17) = 37,734$ cfs.

WAANANEN AND CRIPPEN

$Q_p = 98\,900\,(188.17^{1.029})(188.17^{.5}+5)^{-1.341}$

$= 426,210$ cfs.

MATTHAI $Q = 11,000\,(188.17)^{.61} = 268,453$ cfs.

USE 36,500 cfs.

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 58
Area			**of**
Project	**By**	**Checked**	**Pkg.**
Feature	**Date**	**Date**	**Account**

$\boxed{III}$ RUNOFF

$\boxed{D}$ 10 YEAR FLOOD, FC-6

$T_c = 5.22$ Hours ; $A = 183.17$ Sq. Miles

Try Duration = 3 Hrs. , Retention = 0.1 inches

$$T_p = \frac{3}{2} + .6(5.22) = 4.63$$

$$Q_p = \frac{484\,(188.17)\,(.85-.1)}{4.63} = \quad 14,750 \text{ cfs}$$

Try Duration = 6 Hrs.

$$T_p = \frac{6}{2} + .6(5.22) = \quad 6.13$$

$$Q_p = \frac{484\,(188.17)(1.08-.1)}{6.13} = \quad 14,560 \text{ cfs}$$

Try Duration = 4 Hrs

$$T_p = \frac{4}{2} + .6(5.22) = \quad 5.13$$

$$Q_p = \frac{484\,(188.17)(0.93-.1)}{5.13} = \quad 14,735 \text{ cfs}$$

Check Rational Method

Assume after 8 hrs. runoff is at average rate:

$$Q_p = 1\left(\frac{1.30}{8}\right) 640(183.17) = 19,570 \text{ cfs}$$

Try Duration = 2½ hrs.

$$T_p = \frac{2\frac{1}{2}}{2} + .6(5.22) = \quad 4.38$$

$$Q_p = \frac{484\,(188.17)\,(.8-.1)}{4.38} = \quad 14,550 \text{ cfs}$$

USE 14,750 CFS

STOVEPIPE
WELLS

BASELINE FLOODPLAIN ANALYSIS

Death Valley National Monument
California and Nevada

Flood Mitigation Studies
Package 271

REPORT ON AREAS:

COW CREEK:

FC-1	Park Village
FC-2A	NPS Maintenance
FC-2B	School Wash
FC-2C	Cow Creek Drainage

FURNACE CREEK:

FC-3	NPS Headquarters and Ranch
FC-5	Furnace Creek Inn, Water Supply, & Indian Village
FC-6	Furnace Creek to Zabriskie Point

→ STOVEPIPE WELLS

SP-1	Mosaic Canyon
SP-2	Stovepipe Wells Development

EMIGRANT
- Emigrant Canyon
- Emigrant Ranger Station

MESQUITE CAMPGROUND

SCOTTY'S CASTLE

SC-1	Tie Canyon
SC-2	Castle Area
SC-2	Water Supply
SC-3	Grapevine Canyon

Prepared by:
Dan Overzet, Civil Engineer, DSC
R.F. Brunson, Civil Engineer, DSC
Ron Greslin, Student Engineer, DSC

STOVEPIPE WELLS

GENERAL BACKGROUND

A report by John R. Crippen titled Potential Hazards from Floodflows and Debris Movement in the Furnace Creek Area contains an introduction to the general flood problems, potential hazards, geographic setting, and precipitation for the Death Valley area.

The Task Directive for Flood Mitigation Studies, Packages 271 and 301 approved December 10, 1983, contains the following description:

> "Death Valley has had a long history of flash flood problems. One of the worst in recent times occurred in 1969 when all roads in and out of the valley were severed by flash flooding and many buildings at Furnace Creek, Scotty's Castle, and Stovepipe Wells suffered damage from mud and sheet flow runoff. As in the 1969 event flash flooding can be widespread across the monument, but more often a severe downpour from a thunderstorm occurs in a localized area.
>
> "Stovepipe Wells is on the alluvial fan produced by outwash from Mosaic Canyon in Tucki Mountain (part of the Panamint Range on the west side of the valley). Here is located a National Park Service (NPS) campground, a restaurant, motel, store, gas station, and residences owned by NPS but operated by a concessioner. Flash floods can concentrate in the canyon's several square mile drainage basin and flow out onto the alluvial fan that the development is on. The Stovepipe Wells development is about 2 miles from the mouth of Mosaic Canyon. Flash flood flows across alluvial fans tend to be very unpredictable, forming sheet flows or concentrating in channels in the fan. Because the flows can spread out across the fan they are not as dangerous as flows confined in canyons."

PURPOSE

The purpose of this study is to determine 1) the precipitation and runoff for Mosaic Canyon and the alluvial fan above Stovepipe Wells; 2) the extent of flooding at selected critical sections; and 3) the locations for which some method of flood mitigation should be provided.

STUDY AREA

The areas of concern are Mosaic Canyon and the portion of the alluvial fan above Stovepipe Wells which will contribute to the runoff affecting Stovepipe Wells development. The drainage areas are shown on page 4 and are labeled (1) for Mosaic Canyon and (2) for the alluvial fan above Stovepipe Wells development. Page 5 is a copy of an aerial photograph of the areas and page 6 is a photograph of the Stovepipe Wells development taken from the east. Table 1, on page 7, gives the drainage area characteristics for Area (1) and Area (2).

METHODOLOGY

Precipitation for the 100-year storm was determined using the procedures and isopluvials in NOAA ATLAS 2, Volume XI, prepared by the National Oceanic and Atmospheric Administration. Precipitation for the probable maximum thunderstorm was determined using the procedures and isohyets as prescribed in DESIGN OF SMALL DAMS, Second Edition, Bureau of Reclamation. Precipitation for the areas is summarized in Table 2 on page 8.

Runoff was determined by the procedures described in DESIGN OF SMALL DAMS, and USGS Topographic Map, Stovepipe Wells, California. Runoff is also summarized in Table 2 on page 8.

Flood extents at two locations were determined using Mannings Formula with "n" values of 0.045. The two sections, one at the mouth of Mosaic Canyon and one at the main dike at Stovepipe Wells, were taken on-site. The plan on page 10 showing the dike section location was taken from a one-half size print of Drawing Number 143-41083. The cross-sections are shown on pages 9 and 11.

RESULTS

At the mouth of Mosaic Canyon, a large wash extends down the northwest side of the alluvial fan. The USGS topographic map shown on page 4 was completed in 1952 and shows the drainage to follow the northwest side of the fan. Recent aerial photographs (page 5) and aerial reconnaissance reveal that the present flow from Mosaic Canyon follows washes and channels on the east side of the alluvial fan to the east of the Stovepipe Wells development. The capacity of a critical section occurring at the mouth of Mosaic Canyon determines if the flood waters will be contained in the present wash and continue to be diverted to the east side of the Stovepipe Wells development. This critical section will contain even the probable maximum flood as shown on page 9. Even if the parking area fill which forms one side of the critical channel is breached, the flood waters would apparently follow the old wash on the northwest side of the alluvial fan and not affect the development. Large flows on alluvial fans are unpredictable, however, and the debris carried by the flow could block existing channels and the high velocity of the flood water could scour new channels.

The runoff which affects the Stovepipe Wells development appears to be sheet flow originating from rainfall on Area (2) as shown on page 4. Total runoff from this area amounts to only 220 cubic feet per second for the 100-year flood and 1460 cubic feet per second for the probable maximum flood. The plan on page 10 shows a section (SP-1) of the main dike above the development, and the cross-section is on page 11. The section appears to be capable of containing the 100-year floodflow; but not capable of containing the probable maximum flow. It is questionable, however, that the section will carry even a 25- or 50-year flood for several reasons. The dike is constructed on an almost horizontal grade and will serve more as a detention dam than a diversion dike. Since the dike does not contain a core to reduce the permeability of the dike material, water contained behind the dike will begin seeping through the dike and eventually break through. Also, flood waters

arriving at the dike will lose velocity due to the stilling action of the horizontal dike and will drop their sediment and debris load, thereby filling in the available water carrying channel.

A small drainage ditch within the development is sufficient for removing rainfall runoff which occurs downhill from the main dike.

RECOMMENDATIONS FOR FURTHER STUDY AND FLOOD MITIGATION

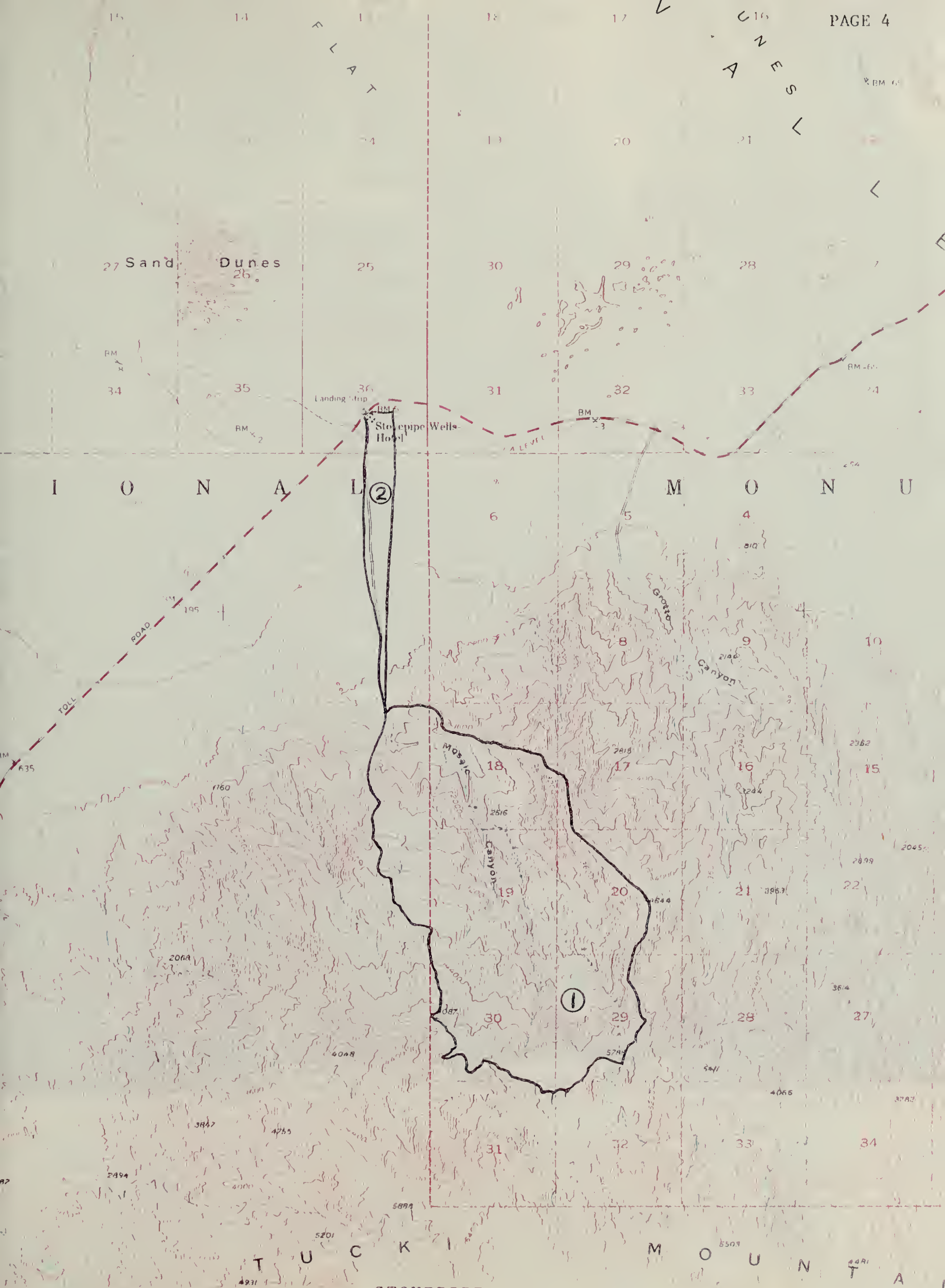
Mosaic Canyon. A riprap wall extending approximately 500 feet from the mouth of the canyon along the west wall of the wash would protect the access road and parking lot for Mosaic Canyon. The riprap would also ensure that flood water remained diverted to the east side of the alluvial fan and would thereby protect the Stovepipe Wells development from flood waters which could otherwise form new channels toward the development.

The riprap would be placed at a 1 on 2 slope against the existing west bank and would be about 9 feet high, the same height of the existing vertical bank. The riprap would only be visible from within the wash. A few additional field sections and measurements would be required to provide the data for determining the wall heights at various locations and total length for preliminary design and estimates.

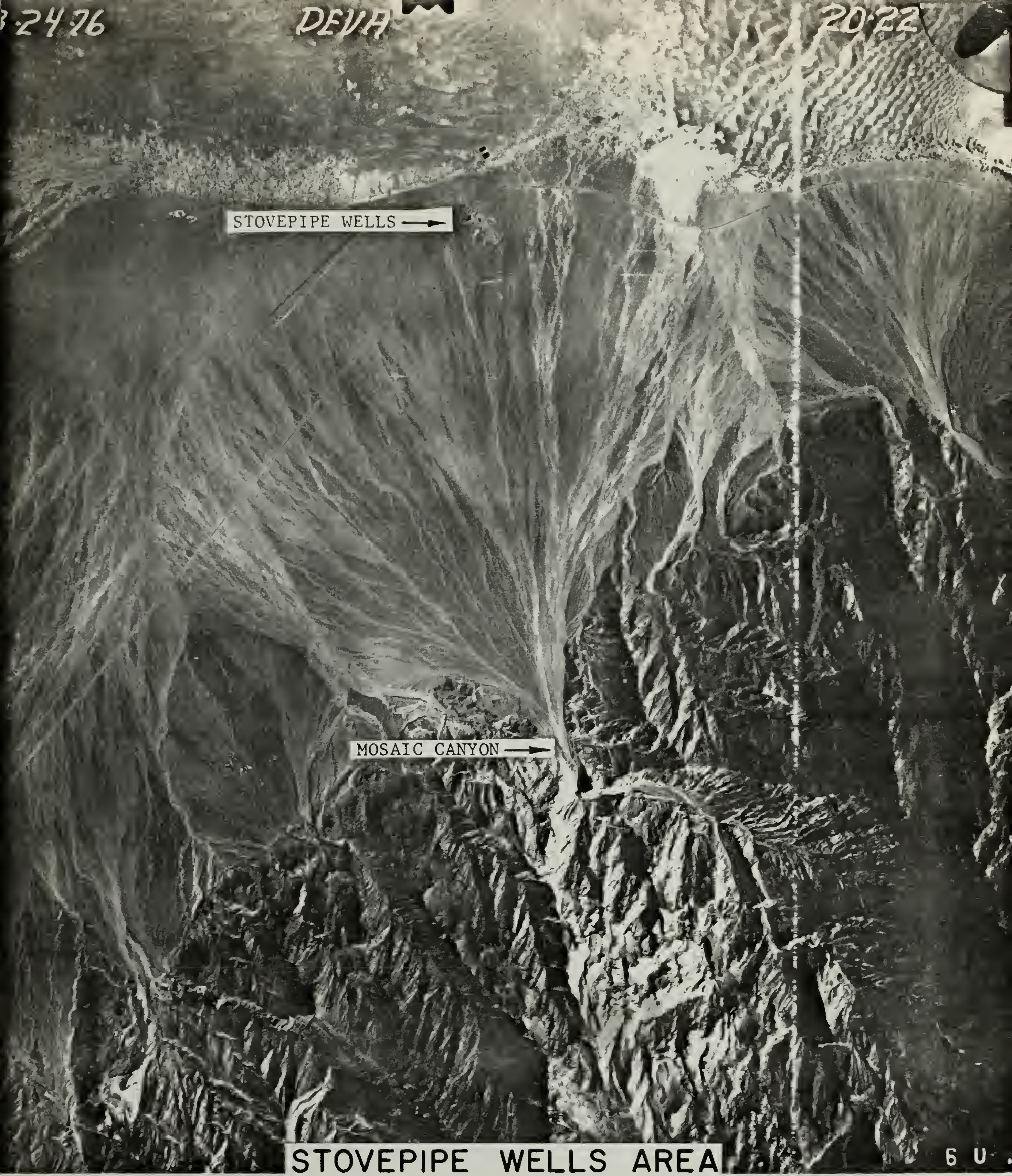
Alluvial Fan. A few earthen diversion dikes placed along the boundaries of Area (2) may prevent channels and washes from other, adjacent drainage areas from relocating into Area (2). Additional aerial and on-site reconnaissance would be required to locate positions for useful preventative dikes.

Stovepipe Wells. The main diversion dike above the development should be repositioned to form a wedge to divide the sheet flow from Area (2) into two channels along the face of the dike. The grade along the base of the dike should be steep enough to maintain the velocity of the flow sufficiently to prevent the deposition of sediment and debris. The flow veolcity should not be excessive, however, which would undermine and erode the dike. The dike should be faced with riprap sized to accommodate the design flow velocities, and the dike should have an impermeable core to prevent water seepage. The existing topographic map, Drawing Number 143-41083, is adequate to design this new dike.

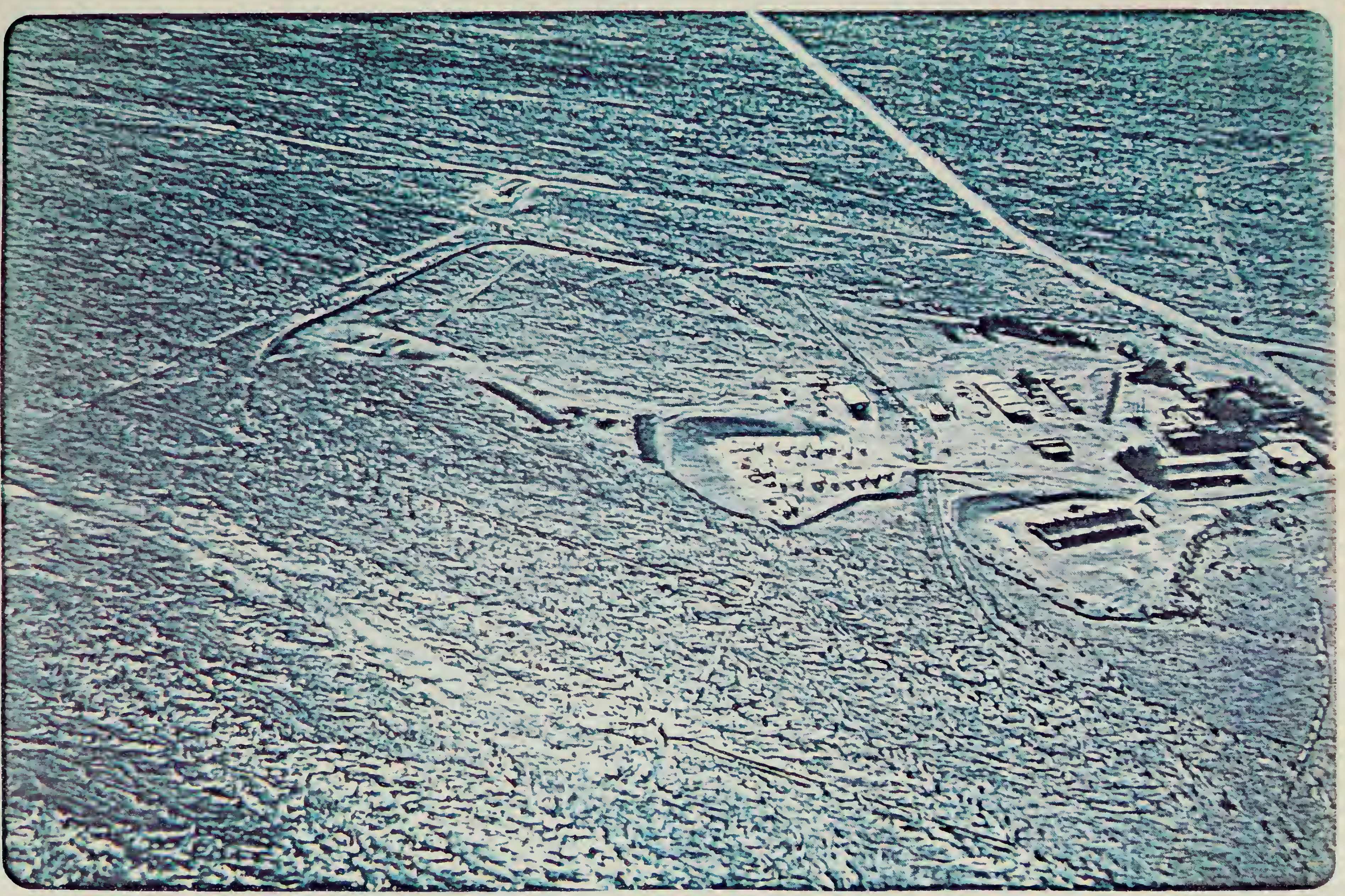
Some reshaping of the drainage channel within the development may be desirable. The existing mounds of soil within the development could be removed; however, grading for drainage around the buildings should be studied and improved.



STOVEPIPE WELLS AREA



STOVEPIPE WELLS AREA



STOVEPIPE WELLS DEVELOPMENT (FROM THE EAST)

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** STOVE PIPE WELLS	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 7 **of**
Project	**By** D. D.	**Checked**	**Pkg.**
Feature	**Date** 2/15/84	**Date**	**Account**

TABLE 1 DRAINAGE AREA CHARACTERISTICS

AREA NAME	AREA $(MI.^2)$	LENGTH (MILES)	TIME OF CONC. (MIN.)	ELEV. MAX. (FEET)	ELEV. MIN. (FEET)	A/E CHANNEL SLOPE
1	4.52	3.9	28.6	5788	960	0.2345
2	0.40	2.4	30.4	960	0	0.0758

TIMES OF CONCENTRATION

$$T_c = \left(\frac{11.9\ L^3}{\Delta E}\right)^{0.385}$$

L = LENGTH IN MILES

T_c = TIME OF CONCENTRATION (HRS.)

ΔE = DIFFERENCE IN ELEVATION (FT.)

AREA 1 MOSAIC CANYON $= \left[\frac{11.9\ (3.9)^3}{5788 - 960}\right]^{0.385} = 0.477$ HRS. = 28.6 MIN.

AREA 2 STOVEPIPE WELLS $= \left[\frac{11.9\ (2.4)^3}{960 - 0}\right]^{0.385} = 0.507$ HRS. = 30.4 MIN.

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 8
Area STOVEPIPE WELLS			of
Project	By D.O.	Checked	Pkg.
Feature	Date	Date	Account

TABLE 2 PRECIPITATION AND RUNOFF

AREA NAME	MOSAIC CANYON	STOVEPIPE WELLS
100 YR. PRECIPITATION		
5 MINUTE	0.30 INCHES	0.30 INCHES
10 MINUTE	0.47 INCHES	0.46 INCHES
15 MINUTE	0.60 INCHES	0.59 INCHES
30 MINUTE	0.78 INCHES	0.81 INCHES
1 HOUR	1.02 INCHES	1.03 INCHES
2 HOUR	1.27 INCHES	1.17 INCHES
3 HOUR	1.44 INCHES	1.25 INCHES
PROBABLE MAXIMUM		
15 MINUTE	2.88 INCHES	2.88 INCHES
30 MINUTE	4.26 INCHES	4.26 INCHES
45 MINUTE	5.28 INCHES	5.28 INCHES
1 HOUR	6.00 INCHES	6.00 INCHES
2 HOUR	7.56 INCHES	7.56 INCHES
3 HOUR	8.04 INCHES	8.04 INCHES
AREA	4.52 $MI.^2$	0.40 $MI.^2$
100 YR. RUNOFF	2775 $FT^3/SEC.$	220 $FT^3/SEC.$
PROBABLE MAXIMUM RUNOFF	17,150 $FT^3/SEC.$	1460 $FT^3/SEC.$

FORM D S C - 44

Park	NATIONAL PARK SERVICE DENVER SERVICE CENTER	Sheet 9
Area		of

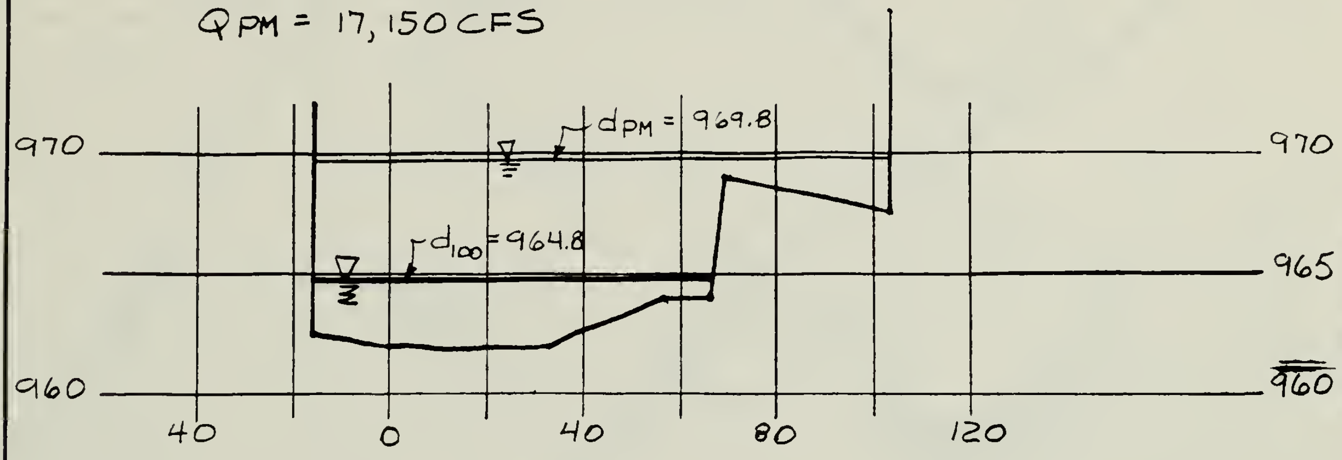
Project	By	Checked	Pkg.
Feature MOSAIC CANYON	Date	Date	Account

SECTIONS

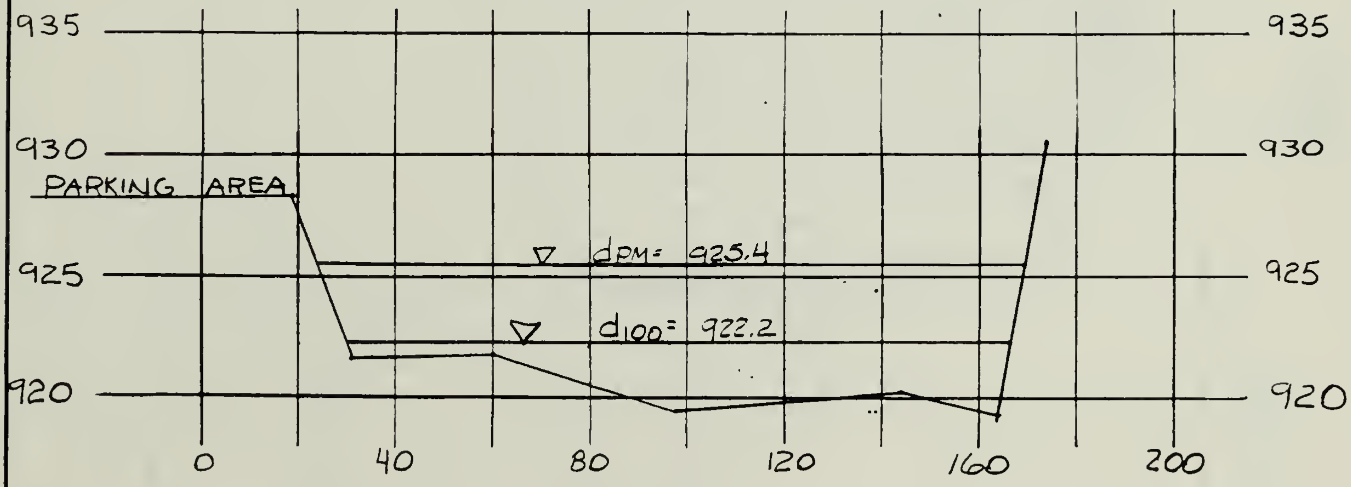
Q_{100} = 2775 CFS

Q_{PM} = 17,150 CFS

S = .08

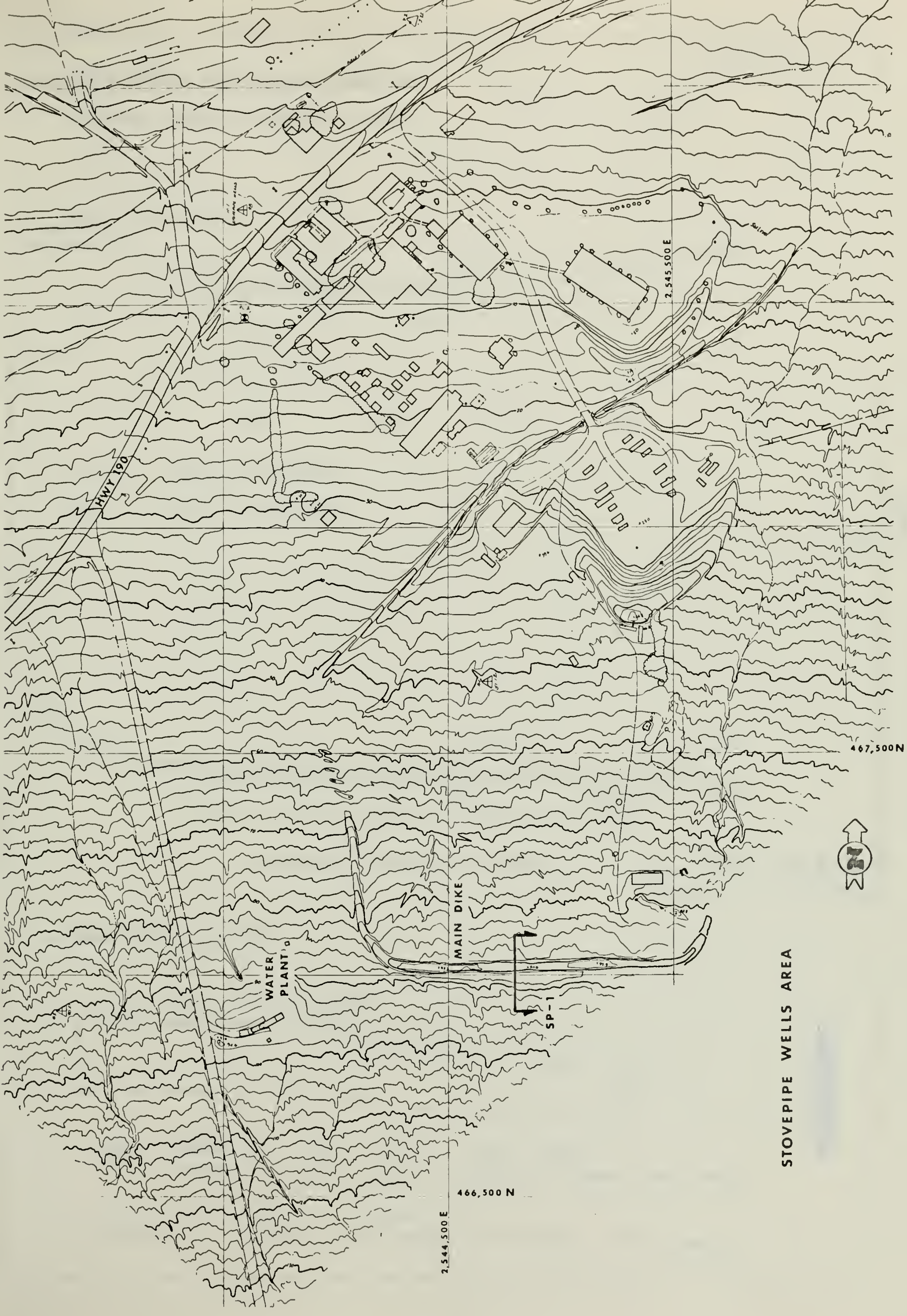


0+00 MC - MOUTH OF MOSAIC CANYON



5+00 MC - MOSAIC CANYON OUTFLOW AT PARKING

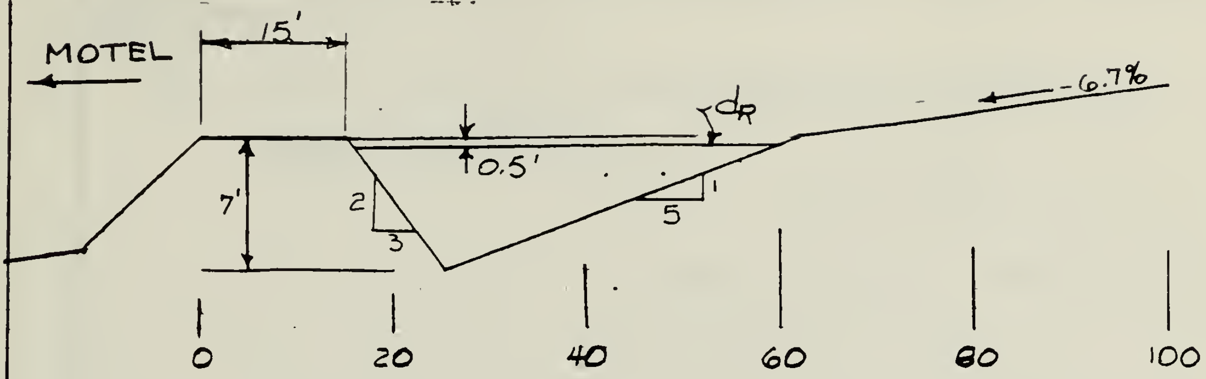
•U.S. GPO: 1984-778-378



STOVEPIPE WELLS AREA

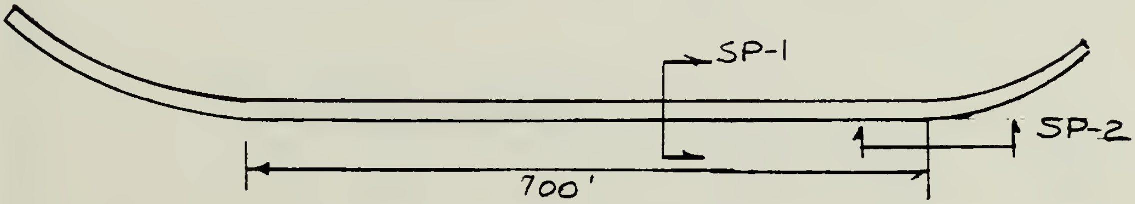
STOVE PIPE WELLS - DIKE

DIKE SECTION: SP-1



Q_{100} = 220 FT³/SEC.

Q_{PMF} = 1460 FT³/SEC.

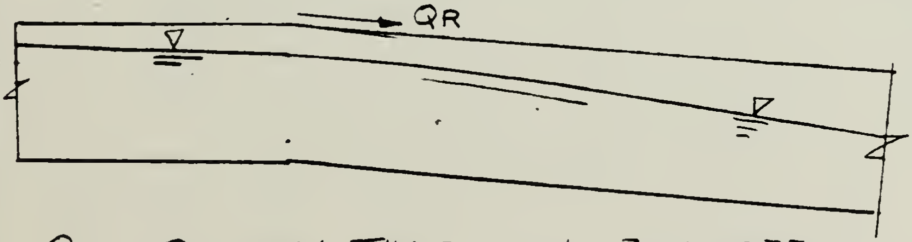


PLAN- MAIN DIKE

Q_{100}/ft = 0.3 ft³/sec.

Q_{PMP}/ft = 2.0 ft³/sec.

SECTION SP-2



Q_R = QUANTITY THAT CAN RUN OFF FROM DIKE = 412 Ft³/SEC. FROM EACH END

Dike will carry Q_{100}

Dike will over flow 636 FT³/SEC. OF Q_{PMP}.

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 12
Area STOVEPIPE WELLS			**of**
Project FLOOD STUDIES	**By** D. OVERZET	**Checked**	**Pkg.**
Feature	**Date** 2/84	**Date**	**Account**

II PRECIPITATION

A FIND PRECIPITATION FOR 100 YR. FREQUENCY

MOSAIC CANYON

6 HR., 100 YR. POINT = 1.3 INCHES = X_3

24 HR., 100 YR. POINT = 3.5 INCHES = X_4

Y_{100} = 100 YR., 1 HR. RAIN = $0.322 + 0.789 \left[X_3 \left({}^{X_3}/_{X_4} \right) \right]$

= 1.05 INCHES/HR.

FIND AMOUNTS FOR VARIOUS DURATIONS

REDUCE FOR AREA

100 YR., 5 MIN. = 0.29 (1.05) = 0.30 IN. → 0.30 IN.

100 YR., 10 MIN. = 0.45 (1.05) = 0.47 IN. → 0.47 IN.

100 YR., 15 MIN. = 0.57 (1.05) = 0.60 IN. → 0.60 IN.

100 YR., 30 MIN. = 0.79 (1.05) = 0.83 IN. → 0.78 IN.

100 YR., 1 HR. = 1 (1.05) = 1.05 IN. → 1.02 IN.

100 YR., 2 HR. = 1.30 INCHES ——→ 1.27 IN.

100 YR., 3 HR. = 1.45 INCHES ——→ 1.44 IN.

STOVEPIPE WELLS

6 HR., 100 YR. POINT = 1.5 INCHES = X_3

24 HR., 100 YR. POINT = 2.5 INCHES = X_4

Y_{100} = 100 YR., 1 HR. RAIN = $0.322 + 0.789 \left[\frac{X_3^2}{X_4} \right]$

= 1.03 INCHES/HR.

FIND AMOUNTS FOR VARIOUS DURATIONS

100 YR., 5 MIN. = 0.29 (1.03) = 0.30 INCHES

100 YR., 10 MIN. = 0.45 (1.03) = 0.46 INCHES

100 YR., 15 MIN. = 0.57 (1.03) = 0.59 INCHES

100 YR., 30 MIN. = 0.79 (1.03) = 0.81 INCHES

100 YR., 1 HR. = 1 (1.03) = 1.03 INCHES

100 YR., 2 HR. = 1.17 INCHES

100 YR., 3 HR. = 1.35 INCHES

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 13
Area STOVEPIPE WELLS AREAS			**of**
Project	**By** D. J.	**Checked**	**Pkg.**
Feature	**Date** 2/14/84	**Date**	**Account**

II PRECIPITATION (CONT.)

B FIND PROBABLE MAXIMUM RAINFALL

1 HOUR POINT RAINFALL = 6 INCHES/HR.

Death Valley lies in Zone I —
No adjustment for area required.

RAINFALL FOR OTHER DURATIONS

15 MIN. = 0.48 (6) = 2.88 INCHES
30 MIN. = 0.71 (6) = 4.26 INCHES
45 MIN. = 0.88 (6) = 5.28 INCHES
1 HR. = 1 (6) = 6.00 INCHES
2 HR. = 1.26 (6) = 7.56 INCHES
3 HR. = 1.34 (6) = 8.04 INCHES

Information for Probable Maximum Rainfall from:
"Design of Small Dams" - by U.S. Dept. of Interior
Bureau of Reclamation — 1974

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** STOVEPIPE WELLS	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 14 **of**
Project	**By** D.O. / **Checked**	**Pkg.**
Feature	**Date** 2/21/84 / **Date**	**Account**

III RUNOFF

$T_p = D/2 + 0.6\,T_c$

$Q_p = \frac{484\,(A)(Q)}{T_p}$

D = Duration (Hrs.)
T_c = Time of Concentration (Hrs.)
A = Area (Mi.²)
Q_T = Total Rainfall for specified duration
Q_c = Peak Flow

A 100 YR. FLOOD

AREA 1 - MOSAIC CANYON

Rainfall retention assumptions: Mountains – 0.1"
Flats – 0.25"

Total Retained – ≈100% Mountains = 0.1"

$T_c = 0.477$ HRS. $A = 4.52$ MI.²

TRY DURATION = 15 MIN.

$T_p = .25/2 + 0.6(0.477) = 0.4112$

$Q_p = \frac{484(4.52)(0.60 - .1)}{0.4112} = 2660$ cfs

TRY DURATION = 30 MIN.

$T_p = .5/2 + 0.6(0.477) = 0.5362$

$Q_p = \frac{484(4.52)(0.78 - .1)}{0.5362} = 2774$ cfs

TRY DURATION = 1 HR.

$T_p = 1/2 + 0.6(0.477) = 0.7862$

$Q_p = \frac{484(4.52)(1.02 - .1)}{0.7862} = 2560$ cfs

TRY RATIONAL METHOD – 30 MIN. STORM (assuming no retention of rainfall after 30 MIN.)

$Q_p = CIA = 1.00\left(\frac{0.78}{1/2\text{ HR.}}\right)(640)(4.52)$

$= 4513$ cfs

TRY RATIONAL METHOD – 1 HR. STORM (no retention after 1 HR.)

$Q_p = CIA = 1.00\left(\frac{1.02}{1\text{ HR.}}\right)(640)(4.52)$

$= 2951$ cfs

USE 2775 cfs

FORM D S C - 44

Park DEATH VALLEY N. M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**			**Sheet** 15
Area STOVEPIPE WELLS				**of**
Project	**By** D.O.		**Checked**	**Pkg.**
Feature	**Date** 2/21/84		**Date**	**Account**

RUNOFF

A 100 YR. FLOOD

AREA 2 - STOVEPIPE WELLS DEVELOPMENT

Rainfall Retention — assume 0.15" on the alluvial fan.

$T_c = 0.507$ HRS. $\qquad A = 0.40$ MI.^{2}

TRY DURATION = 15 MIN.

$T_p = 0.25/2 + 0.6(0.507) = 0.4292$

$$Q_p = \frac{484(0.40)(0.60-0.15)}{0.4292} = 203 \text{ cfs}$$

TRY DURATION = 30 MIN.

$T_p = 0.5/2 + 0.6(0.507) = 0.5542$

$$Q_p = \frac{484(0.40)(0.78-0.15)}{0.5542} = 220 \text{ cfs}$$

TRY DURATION = 1 HR.

$T_p = 1/2 + 0.6(0.507) = 0.8042$

$$Q_p = \frac{484(0.40)(1.02-0.15)}{0.8042} = 209 \text{ cfs}$$

TRY RATIONAL METHOD — 30 MIN. STORM (assume no retention by soil after 30 MIN.)

$$Q_p = CIA = 1.00\left(\frac{0.78}{1/2 \text{ HR.}}\right)640(0.40)$$

$$= 399 \text{ cfs}$$

TRY RATIONAL METHOD — 1 HR. STORM (assume no retention by soil after 1 HR.)

$$Q_p = CIA = 1.00\left(\frac{1.02}{1 \text{ HR.}}\right)640(0.40)$$

$$= 261 \text{ cfs}$$

USE 220 cfs

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** STOVEPIPE WELLS	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 16 **of**
Project	**By** D.J.	**Checked**	**Pkg.**
Feature	**Date** 2/21/84	**Date**	**Account**

III RUNOFF

$T_p = D/2 + 0.6\,T_c$

$Q_p = \dfrac{484(A)(Q_r)}{T_p}$

D = Duration (Hrs.)
T_c = Time of Concentration (Hrs.)
A = Area (Mi²)
Q_r = Total Rainfall for specified duration
Q_p = Peak Flow

B PMP FLOOD

AREA 1 - MOSAIC CANYON

Rainfall retention assumptions : Mountains - 0.1"
Flats - 0.25"

Total Retained - ≈ 100% Mountains = 0.1"

$T_c = 0.477$ HRS. $A = 4.52$ MI.²

TRY DURATION = 15 MIN.

$T_p = 0.25/2 + 0.6(0.477) = 0.4112$

$Q_p = \dfrac{484(4.52)(2.38 - 0.1")}{0.4112} = 14{,}790$ cfs

TRY DURATION = 30 MIN.

$T_p = 0.5/2 + 0.6(0.477) = 0.5362$

$Q_p = \dfrac{484(4.52)(4.26 - 0.1)}{0.5362} = 16{,}973$ cfs

TRY DURATION = 45 MIN.

$T_p = 0.75/2 + 0.6(0.477) = 0.6612$

$Q_p = \dfrac{484(4.52)(5.28 - 0.1)}{0.6612} = 17{,}139$ cfs

TRY DURATION = 1 HR. MIN.

$T_p = 1/2 + 0.6(0.477) = 0.7862$

$Q_p = \dfrac{484(4.52)(6 - 0.1)}{0.7862} = 16{,}417$ cfs

TRY RATIONAL METHOD - 30 MIN STORM (assume no retention of rainfall after 30 MIN.)

$Q_p = CIA = 1.00\left(\dfrac{4.26}{1/2\ \text{HR.}}\right)640(4.52)$
$= 24{,}647$ cfs

TRY RATIONAL METHOD - 45 MIN. STORM (assume no retention after 1 HR)

$Q_p = CIA = 1.00\left(\dfrac{5.28}{1\ \text{HR.}}\right)640(4.52)$
$= 15{,}274$ cfs

USE 17,150 CFS

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 17
Area STOVEPIPE WELLS			**of**
Project	**By** D. O.	**Checked**	**Pkg.**
Feature	**Date** 2/21/84	**Date**	**Account**

III RUNOFF

3 PMP FLOOD

AREA 2 - STOVEPIPE WELLS DEVELOPMENT

Rainfall Retention - assume 0.15" on the alluvial fan.

$T_c = 0.507$ HRS. $A = 0.40$ MI.^{2}

TRY DURATION = 15 MIN.

$T_p = 0.25/2 + 0.6(0.507) = 0.4292$

$$Q_p = \frac{484(0.40)(2.88-0.15)}{0.4292} = 1231 \text{ cfs}$$

TRY DURATION = 30 MIN.

$T_p = 0.5/2 + 0.6(0.507) = 0.5542$

$$Q_p = \frac{484(0.40)(4.26-0.15)}{0.5542} = 1436 \text{ cfs}$$

TRY DURATION = 45 MIN.

$T_p = 0.75/2 + 0.6(0.507) = 0.6792$

$$Q_p = \frac{484(0.40)(5.28-0.15)}{0.6792} = 1462 \text{ cfs}$$

TRY RATIONAL METHOD - 30 MIN. STORM (assume no retention by soil after 30 MIN.)

$$Q_p = CIA = 1.00\left(\frac{4.26}{\tfrac{1}{2}\text{HR.}}\right)640(0.40)$$

$$= 2181 \text{ cfs}$$

TRY RATIONAL METHOD - 45 MIN. STORM (assume no retention by soil after 45 min.)

$$Q_p = CIA = 1.00\left(\frac{5.28}{0.75\text{ HR.}}\right)640(0.40)$$

$$= 1802 \text{ cfs}$$

USE 1460 cfs

EMIGRANT
RANGER
STATION

BASELINE FLOODPLAIN ANALYSIS

Death Valley National Monument
California and Nevada

Flood Mitigation Studies
Package 271

REPORT ON AREAS:

COW CREEK:

FC-1	Park Village
FC-2A	NPS Maintenance
FC-2B	School Wash
FC-2C	Cow Creek Drainage

FURNACE CREEK:

FC-3	NPS Headquarters and Ranch
FC-5	Furnace Creek Inn, Water Supply, & Indian Village
FC-6	Furnace Creek to Zabriskie Point

STOVEPIPE WELLS

SP-1	Mosaic Canyon
SP-2	Stovepipe Wells Development

→ EMIGRANT

Emigrant Canyon
Emigrant Ranger Station

MESQUITE CAMPGROUND

SCOTTY'S CASTLE

SC-1	Tie Canyon
SC-2	Castle Area
SC-2	Water Supply
SC-3	Grapevine Canyon .

Prepared by:
Dan Overzet, Civil Engineer, DSC
R.F. Brunson, Civil Engineer, DSC
Ron Greslin, Student Engineer, DSC

EMIGRANT CANYON RANGER STATION

GENERAL BACKGROUND

An introduction to the general flood problems of Death Valley, geographic setting, and general discussion of precipitation are included in a study titled Potential Hazards from Floodflows and Debris Movement in the Furnace Creek Area, by John R. Crippen, USGS.

The Task Directive for Flood Mitigation Studies, Packages 271 and 301, approved on December 10, 1983, discusses obtaining baseline data for several areas including Emigrant Ranger Station. The information that the studies should provide is also addressed.

Emigrant Ranger Station area includes the ranger station with attached ranger's residence, a travel trailer with utilities, a comfort station, and a 10-site campground. The ranger station is 1.75 miles downhill from the mouth of Emigrant Canyon, and is also 4.5 miles downhill from the mouth of Towne Pass canyon. The station is near the junction of Highway 190 and Highway 178.

PURPOSE

The purpose of this study is to determine (1) the precipitation and runoff for Emigrant Canyon and Towne Pass which concurrently or separately will produce the maximum 100-year and probable maximum flood at the Emigrant Ranger Station; (2) the extent of flooding at selected critical sections; and (3) the locations for which some method of flood mitigation should be provided.

STUDY AREA

The areas of concern for this report include the portion of the Towne Pass drainage basin which will contribute runoff to the Emigrant Ranger Station Wash; the drainage basin which will contribute directly to Emigrant Canyon; and the Harrisburg Flats basin which contributes to Emigrant Canyon. The drainage areas are shown on pages 4 and 5, and are labeled (1) for Towne Pass, (2) for Emigrant Canyon, and (3) for Harrisburg Flats. Page 6 is a copy of a photograph showing the mouth of the Towne Pass canyon, the mouth of Emigrant Canyon, and the Emigrant Ranger Station location. The maximum runoff which will affect the ranger station area for the 100-year and probable maximum precipitation will depend on the basin characteristics of the three areas either contributing independently or in combination. The characteristics of the separate and combined basins are given in Table 1 on page 7.

METHODOLOGY

Precipitation for the 100-year storm was determined using the procedures and isopluvials in NOAA ATLAS 2, Volume XI, prepared by the National Oceanic and Atmospheric Administration. Precipitation for the probable maximum thunderstorm was determined using the procedures and isohyets as prescribed in DESIGN OF SMALL DAMS, Second Edition, Bureau of Reclamation. Precipitation for the areas and combinations of areas is summarized in Table 2 on page 8.

Runoff was determined by the procedures described in DESIGN OF SMALL DAMS, and USGS Topographic Maps, Emigrant Canyon and Panamint Butte, California. Since areas have their precipitation and rainfall intensity adjusted for size, and since combinations of areas have varying times of concentration, several separate and combined areas were examined to determine the maximum rates of runoff. Runoffs for the areas and combinations of areas are also summarized in Table 2 on page 8.

Flood extents at two locations were determined using Manning's Formular with "n" values of 0.045. The two sections, one at the mouth of Emigrant Canyon and one at the wash adjacent to the Emigrant Ranger Station, were taken on-site. The cross-sections are shown on pages 9 and 10.

RESULTS

The USGS topographic map of Emigrant Canyon on page 4 and the aerial photograph on page 6 indicate that the runoff from Emigrant Canyon follows Emigrant Wash which is 700 to 1000 feet west of the ranger station. On-site and aerial examination revealed, however, that the drainage channel at the mouth of Emigrant Canyon will carry only the normally small flows which occur relatively frequently. Larger flows generated by storms of 50 years or longer recurrence will overflow the channel at a critical section near the mouth and flow into the drainage from Towne Pass.

The combined runoff from the Towne Pass, Emigrant Canyon, and Harrisburg Flats drainage areas produced the maximum peak flows for both the 100-year and the probable maximum floods. The large, almost basin-like shape of Harrisburg Flats may affect the validity of the soil percolation assumptions; however, the combined effect of Towne Pass and Emigrant Canyon drainages produced almost the same results. The flows reaching the Emigrant Ranger Station area have been reduced by the amount of flow remaining in the Emigrant Wash.

The critical section for the mouth of Emigrant Canyon is shown on page 9. Some of the runoff will overflow into Towne Pass drainage which will threaten the Emigrant Ranger Station.

A cross-section of the wash adjacent to the Emigrant Ranger Station is shown on page 10. The wash will contain the maximum flood.

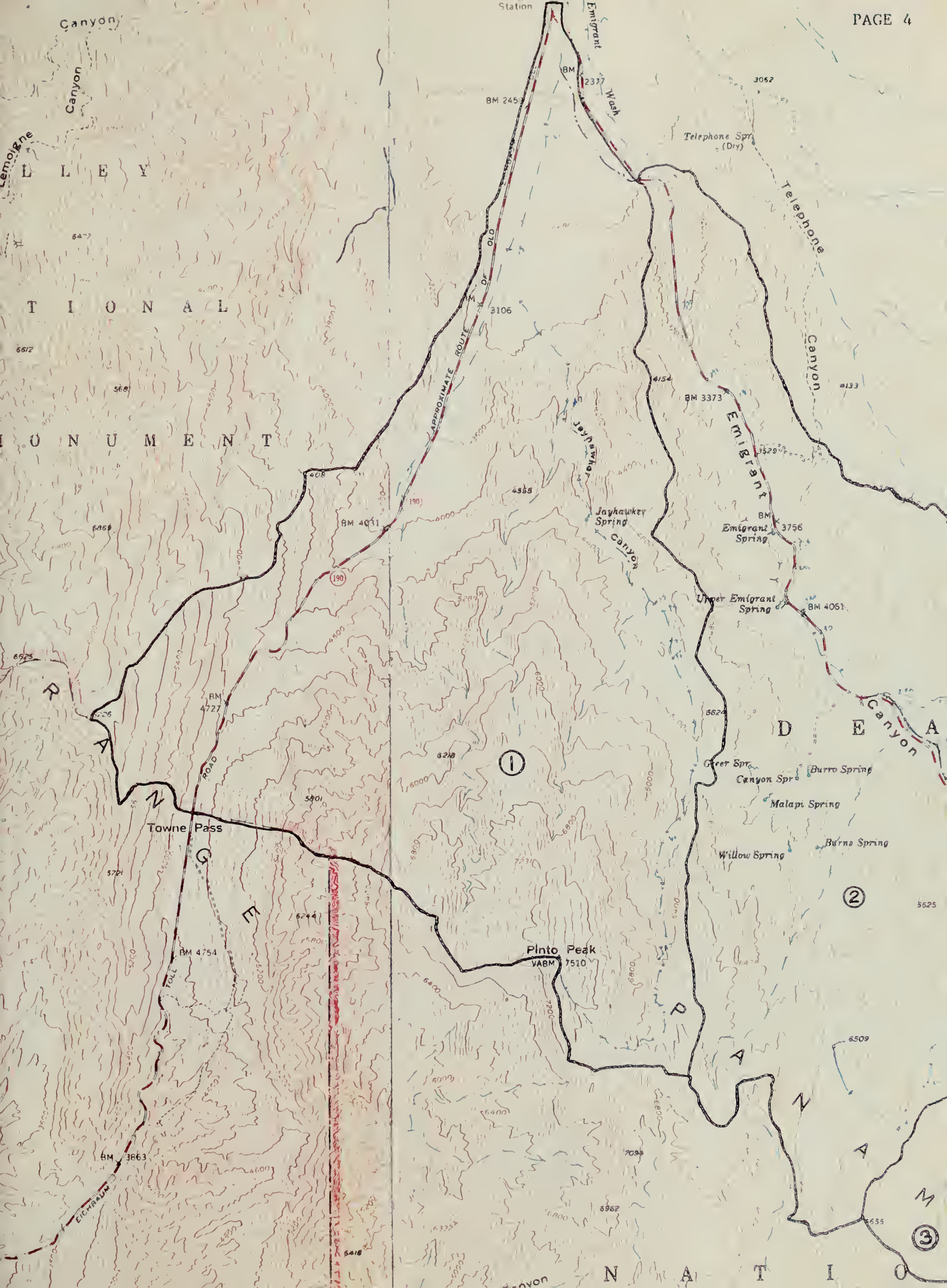
RECOMMENDATIONS FOR FURTHER STUDY AND FLOOD MITIGATION

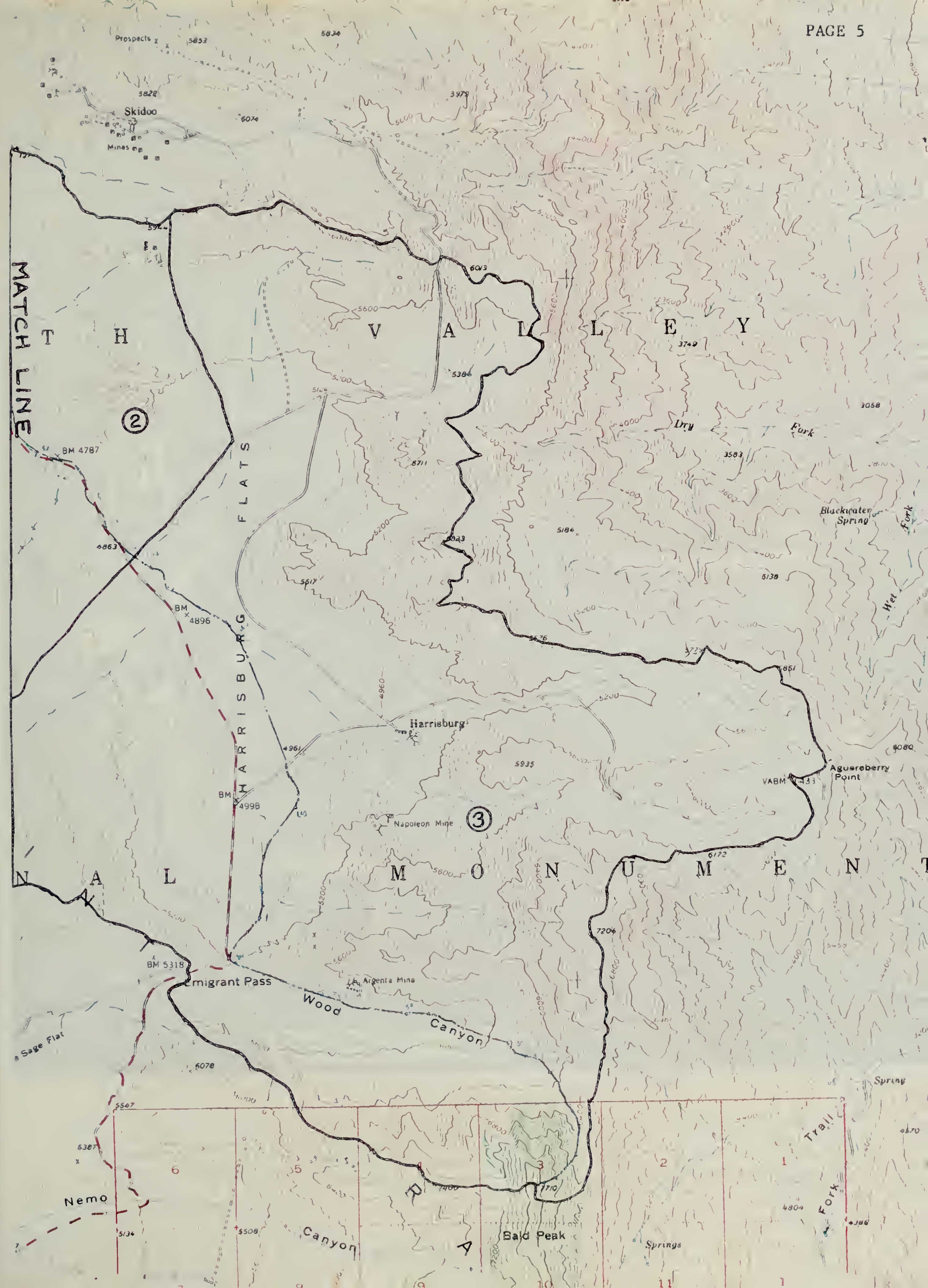
Emigrant Canyon: The critical section near the mouth of Emigrant Canyon could be widened to increase capacity, and a dip in Highway 178 to accommodate larger flows without damage to the highway could be installed. Some additional field measurements would be required to prepare preliminary designs and estimates.

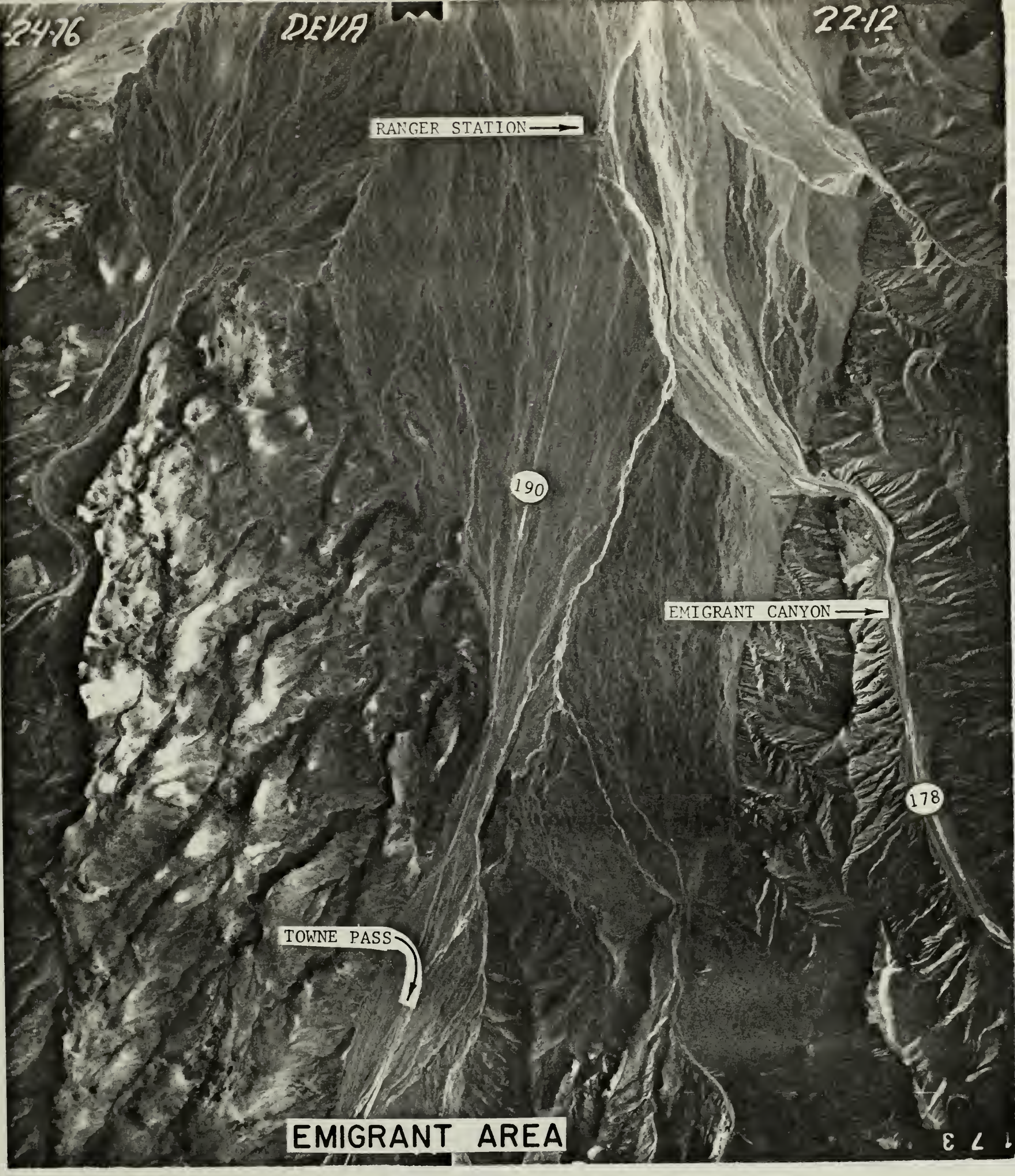
Emigrant Junction: Near the junction of Highway 178 and Highway 190, a diversion dike upstream of Highway 178 and a dip in Highway 178 are necessary to protect the highways and to ensure that the combined design flow remains within a predictable channel. A survey crew obtained the necessary basic data in October, 1984.

Emigrant Ranger Station: The wash will contain the maximum flows; however, the high velocities of 8 to 17 feet per second for the 100-year and greater floods require that the channel adjacent to the ranger station be lined. Large quarry-stone riprap extending a few hundred feet upstream from the ranger station would be the probable solution. The riprap would need to be keyed into the streambed for three to four feet and would be placed at a 1 on 2 slope to about 9 feet high. The dike may need to be heightened or thickened in places to provide adequate support for the riprap. The riprap construction would not be visible outside of the wash.

In the Spring of 1984, a survey crew obtained basic field data by which preliminary drawings and estimates can be made.


Station
Emigrant Wash
Canyon
Canyon
Lemoigne
L L E Y
T I O N A L
O N U M E N T
R A N G E
Telephone Spr (Dry)
Telephone Canyon
3052
BM 2377
BM 245
OLD
APPROXIMATE ROUTE OF
BM 3106
BM 4031
190
190
408
4154
BM 3373
Emigrant Canyon
3529
BM 3756
Emigrant Spring
Jayhawker Spring
Jayhawker Canyon
4133
6356
Upper Emigrant Spring
BM 4061
BM 4727
ROAD
Towne Pass
5721
6612
5681
6869
6625
7226
5801
6218
①
6624
D E A
Canyon
Greer Spr
Canyon Spr
Burro Spring
Malapi Spring
Willow Spring
Burns Spring
②
5625
7310
6244
BM 4754
TOLL
Pinto Peak
VABM 7510
P A N A M
6509
7094
6962
5635
③
BM 3863
EICHBAUM
6418
N A T I O
Canyon


Prospects
Skidoo
Mines
MATCH LINE
T H
V A L L E Y
②
③
BM 4787
BM 4896
BM 4998
BM 5318
HARRISBURG FLATS
Harrisburg
Napoleon Mine
N A L
M O N U M E N T
Dry Fork
Blackwater Spring
Wet Fork
Aguereberry Point
VABM 6433
Emigrant Pass
Argenta Mine
Wood Canyon
Sage Flat
Nemo
Canyon
R A
Bald Peak
Springs
Spring
Trail
Fork
6
5
4
3
2
1
1
7
8
9
10
11



EMIGRANT AREA

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 7
Area EMIGRANT RANGER. STA.		**of**
Project	**By** D.O. / **Checked**	**Pkg.**
Feature	**Date** 2/15/84 / **Date**	**Account**

TABLE 1 - DRAINAGE AREA CHARACTERISTICS

AREA NAME	AREA (MI^2)	LENGTH (MILES)	TIME OF CONC. (MIN.)	ELEV. MAX. (FEET)	ELEV. MIN (FEET)	AVE CHANNEL SLOPE
1	20.98	10.5	86.4	7510	2160	0.0965
2	19.31	10.45	98.1	6509	2720	0.0687
1+2	40.79	11.95	114.5	6509	2160	0.0689
2+3	49.63	16.2	146.4	7710	2720	0.0583
1+2+3	70.61	17.75	156.1	7710	2160	0.0592

TIMES OF CONCENTRATION

$$T_c = \left(\frac{11.9\ L^3}{\Delta E}\right)^{0.335}$$

L = LENGTH IN MILES

T_c = TIME OF CONCENTRATION (HRS.)

ΔE = DIFFERENCE IN ELEVATION (FT.)

AREA 1 (Towne Pass) $= \left[\frac{11.9\,(10.5)^3}{7510-2160}\right]^{0.385} = 1.44$ HRS = 86.4 MIN.

AREA 2 (Emigrant Canyon) $= \left[\frac{11.9\,(10.45)^3}{6509-2720}\right]^{0.335} = 1.63$ HRS = 98.1 MIN.

AREAS 2+3 (Emigrant Pass – Harrisburg Flats) $= \left[\frac{11.9\,(16.2)^3}{7710-2720}\right]^{0.335} = 2.44$ HRS. = 146.4 MIN.

AREAS 1+2+3 $= \left[\frac{11.9\,(17.75)^3}{7710-2160}\right]^{0.385} = 2.60$ HRS. = 156.1 MIN.

AREAS 1+2 $= \left[\frac{11.9\,(11.95)^3}{6509-2160}\right]^{0.385} = 1.91$ HRS. = 114.5 MIN.

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** EMIGRANT	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 3 **of**
Project	**By** D.O. / **Checked**	**Pkg.**
Feature	**Date** / **Date**	**Account**

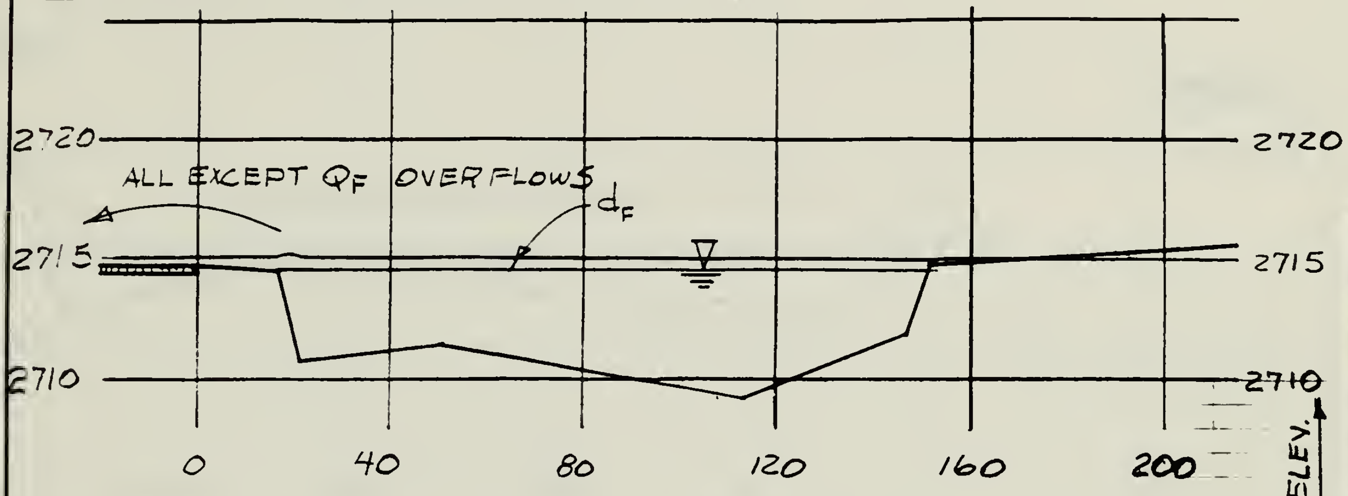
TABLE 2 PRECIPITATION AND RUNOFF

	AREA 1 - TOWNE PASS	AREA 2 - EMIGRANT CANYON	AREAS 1 + 2	AREAS 2+3 EMIGRANT + HARRISBURG	AREAS 1+2+3
100 YR. PRECIPITATION					
5 MINUTES	0.30 IN.	0.30 IN.	0.30 IN.	0.30 IN.	0.30 IN.
10 MINUTES	0.46 IN.	0.46 IN.	0.46 IN.	0.46 IN.	0.46 IN.
15 MINUTES	0.59 IN.	0.59 IN.	0.59 IN	0.59 IN	0.59 IN.
30 MINUTES	0.67 IN.	0.67 IN.	0.59 IN.	0.56 IN.	0.52 IN.
1 HOUR	0.92 IN.	0.92 IN.	0.85 IN.	0.82 IN.	0.78 IN.
2 HOURS	1.15 IN.	1.15 IN.	1.09 IN.	1.06 IN.	1.02 IN.
3 HOURS	1.43 IN.	1.43 IN.	1.37 IN.	1.35 IN.	1.31 IN.
PROBABLE MAXIMUM					
15 MINUTE	2.07 IN.	2.10 IN.	1.81 IN.	1.73 IN.	1.53 IN.
30 MINUTE	3.07 IN.	3.11 IN.	2.68 IN.	2.56 IN.	2.26 IN.
45 MINUTE	3.80 IN.	3.85 IN.	3.33 IN.	3.17 IN.	2.80 IN.
1 HOUR	4.32 IN.	4.38 IN.	3.78 IN.	3.60 IN.	3.18 IN.
2 HOURS	—	—	—	—	—
3 HOURS	—	—	—	—	—
AREA	20.98 $MI.^2$	19.81 $MI.^2$	40.79 $MI.^2$	49.63 $MI.^2$	70.61 $MI.^2$
100 YR. RUNOFF	6000 FT^3/SEC	5250 $FT^3/SEC.$	8900 FT^3/SEC	9375 $FT^3/SEC.$	13,200 FT^3/SEC
PROBABLE MAXIMUM RUNOFF	31,275 $FT^3/SEC.$	27,670 FT^3/SEC	43,900 FT^3/SEC	42,325 $FT^3/SEC.$	50,500 FT^3/SEC
100 YR. RUNOFF AT RANGER STA.	6000 FT^3/SEC	0	6,000 FT^3/SEC	375 FT^3/SEC	6,000 FT^3/SEC
PROBABLE MAX. AT RANGER STA.	31,275 FT^3/SEC	18,600 FT^3/SEC	34,900 FT^3/SEC	33,300 FT^3/SEC	41,500 FT^3/SEC

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 9
Area			**of**
Project EMIGRANT CANYON	**By** BRUNSON	**Checked**	**Pkg.**
Feature CRITICAL SECTION	**Date**	**Date**	**Account**

EMIGRANT CANYON OVERFLOW



Q_{100} = 9375 CFS
Q_{PM} = 42, 325 CFS
Q_F = Capacity of Section

FROM $\frac{Q}{A} = V = \frac{1.486}{n} \cdot \left(\frac{A}{P}\right)^{2/3} S^{1/2}$

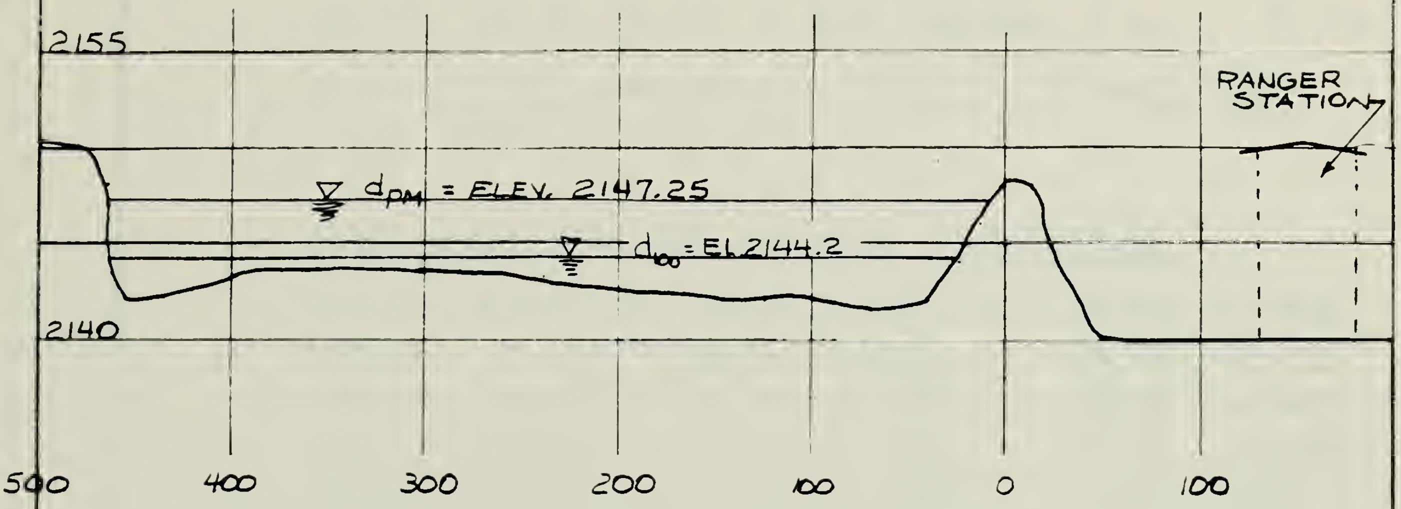
$A = 510$
$P = 137$
$n = .045$
$S = 0.05$

Q_F = 9000 CFS

Q_{PMP} For the Ranger Station = 50,500 - 9000 = 41,500
Q_{100} For the " " = 6,000 cfs (Area 1 governs)

d_F = ELEV. 2714.6

EMIGRANT RANGER STATION



S = 0.06

n = 0.045

Q_{PM} = 41,500 CFS

ELEV. OF d_{PMP} = 2147.25

Q_{100} = 6,000 CFS

ELEV. OF d_{100} = 2144.2

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 11
Area EMIGRANT RANGER STATION			**of**
Project FLOOD STUDIES	**By** D. DIERZET	**Checked**	**Pkg.**
Feature	**Date** 2 84	**Date**	**Account**

II PRECIPITATION

A FIND PRECIPITATION FOR 100 YR. FREQUENCY

ALL AREAS

6 HR., 100 YR. POINT = 1.9 INCHES = X_3 P. 37

24 HR., 100 YR. POINT = 4.0 INCHES = X_4 P. 43

Y_{100} = 100 YR., 1 HR. RAIN = $0.322 + 0.789\left[\left(\frac{X_3^2}{X_4}\right)\right]$

= 1.03 INCHES / HR.

FIND AMOUNTS FOR VARIOUS DURATIONS - P.17

100 YR., 5 MIN. = 0.29 (1.03) = 0.30 INCHES
100 YR., 10 MIN. = 0.45 (1.03) = 0.46 INCHES
100 YR., 15 MIN. = 0.57 (1.03) = 0.59 INCHES
100 YR., 30 MIN. = 0.79 (1.03) = 0.81 INCHES
100 YR., 1 HR. = 1 (1.03) = 1.03 INCHES
100 YR., 2 HR. = 1.25 INCHES
100 YR., 3 HR. = 1.50 INCHES

REDUCE FOR AREA SIZE - P.13

AREA	30 MIN	1 HR.	2 HR.	3 HR.	6 HR.
1	0.67	0.92	1.15	1.43	1.83
2	0.67	0.92	1.15	1.43	1.83
1+2	0.59	0.85	1.09	1.37	1.78
2+3	0.56	0.82	1.06	1.35	1.76
1+2+3	0.52	0.78	1.02	1.31	1.73

Information from NOAA Atlas 2 - Volume XI for California.

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** EMIGRANT RANGER STATION	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 12 **of**
Project	**By** D.O.	**Checked**	**Pkg.**
Feature	**Date** 2/4/84	**Date**	**Account**

II PRECIPITATION (CONT.)

3 FIND PROBABLE MAXIMUM RAINFALL

1 HOUR POINT RAINFALL = 6 INCHES/HR.

The Death Valley area lies in Zone II —
ADJUST FOR AREA.

AREA				
1	0.72 (6)	=	4.32	INCHES/HR.
2	0.73 (6)	=	4.38	INCHES/HR.
1+2	0.63 (6)	=	3.78	INCHES/HR.
2+3	0.60 (6)	=	3.60	INCHES/HR.
1+2+3	0.53 (6)	=	3.18	INCHES/HR.

AREA	15 MIN. 48% of 1HR	30 MIN. 71% of 1HR.	45 MIN. 88% of 1HR.	1 HR. 100% of 1HR.	2HR.	3HR.
1	2.07	3.07	3.80	4.32	NOT APPLICABLE T-STORMS WILL NOT OCCUR LONGER THAN 1HR. P.52	NOT APPLICABLE T-STORMS WILL NOT OCCUR LONGER THAN 1HR. P.52
2	2.10	3.11	3.35	4.38		
1+2	1.81	2.68	3.33	3.78		
2+3	1.73	2.56	3.17	3.60		
1+2+3	1.53	2.26	2.80	3.18		

Information for Probable Maximum Rainfall from:
"Design of Small Dams" - by U.S. Dept. of Interior
Bureau of Reclamation - 1974

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** EMIGRANT	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 13 **of**
Project	**By** D.D.	**Checked**	**Pkg.**
Feature	**Date** 2/84	**Date**	**Account**

III RUNOFF

A 100 YR. FLOOD

$T_P = D/2 + .6\,T_C$ D = DURATION OF STORM (HRS.), T_C = TIME OF CONCENTRATION (HRS.)

$Q_P = \dfrac{484\,(A)\,Q_T}{T_P}$ A = AREA (MI²) Q_T = TOTAL RAINFALL FOR SPECIFIED DURATION

AREA - TOWNE PASS Q_P = peak flow at Emigrant Ranger Station.

Assume .1" rain retained in mountain areas - 85% = .085
Assume .25 " " , flat areas - 15% = .0375
.1225" retained.

T_C = 1.44 HRS. A = 20.98 MI.²

TRY DURATION = 30 MIN.

$T_P = .5/2 + .6(1.44) = 1.114$

$Q_P = \dfrac{484\,(20.98)(0.67 - .12)}{1.114} = 5013$ cfs.

TRY DURATION = 1 HR.

$T_P = 1/2 + .6(1.44) = 1.364$

$Q_P = \dfrac{484\,(20.98)(.92 - .12)}{1.364} = 5956$ cfs.

TRY DURATION = 2 HR.

$T_P = 2/2 + .6(1.44) = 1.864$

$Q_P = \dfrac{484\,(20.98)(1.15 - .12)}{1.864} = 5611$ cfs.

TRY RATIONAL METHOD : 2 HR. STORM

assume no retention on soil after 2HR.

$Q_P = CIA = 1.00\left(\dfrac{1.15''}{2\ \text{HRS}}\right) 640\,(20.98) = 7{,}721$ cfs.

USE 6000 cfs

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 14
Area EMIGRANT			**of**
Project	**By** D. O.	**Checked**	**Pkg.**
Feature	**Date** 2-7-84	**Date**	**Account**

III RUNOFF

A 100 YR. FLOOD

AREA 2 - EMIGRANT CANYON

Rainfall retention assumptions: Mountains – 0.1"
Flats – 0.25"

Total retained: 10% flats x .25 + 90% Mount. x .1 = .115 INCHES

$T_C = 1.63$ HRS $A = 19.31$ MI.^{2}

TRY DURATION = 30 MIN.

$T_P = {.5}/{2} + .6(1.63) = 1.228$

$$Q_P = \frac{434(19.31)(0.57-.115)}{1.228} = 4333 \text{ cfs}$$

TRY DURATION = 1 HR.

$T_P = 1/2 + .6(1.63) = 1.478$

$$Q_P = \frac{434(19.31)(0.92-.115)}{1.478} = 5222 \text{ cfs}$$

TRY DURATION = 2 HR.

$T_P = 2/2 + .6(1.63) = 1.978$

$$Q_P = \frac{434(19.31)(1.5-.115)}{1.978} = 5017 \text{ cfs.}$$

TRY RATIONAL METHOD – 2 HR. STORM – no retention of rainfall after 2 HRS.

$$Q_P = CIA = 1.00\left(\frac{1.15}{2\text{ HR.S}}\right)640(19.31) = 7290 \text{ cfs.}$$

USE 5250 cfs

FORM D S C - 44

Park DEATH VALLEY N.M. Area EMIGRANT	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 15 of
Project	By D.O.	Checked	Pkg.
Feature	Date 3/84	Date	Account

III RUNOFF

A 100 YR. FLOOD

AREAS 1 AND 2 - TOWNE PASS AND EMIGRANT CANYON

Rainfall Retention Assumptions : Mountains - 0.1"
Flats - 0.25"

Total retained - Ave. 1&2 = 0.12"

T_c = 1.91 HRS. AREA = 40.79 MI.^{2}

TRY DURATION = 1HR.

$$T_p = 1/2 + 0.6(1.91) = 1.646$$

$$Q_p = \frac{484\,(40.79)(.85-.12)}{1.646} = 8756 \text{ cfs}$$

TRY DURATION = 2HRS.

$$T_p = 2/2 + 0.6(1.91) = 2.146$$

$$Q_p = \frac{484\,(40.79)(1.09-.12)}{2.146} = 8924 \text{ cfs}$$

TRY DURATION = 3 HRS.

$$T_p = 3/2 + 0.6(1.91) = 3.146$$

$$Q_p = \frac{484\,(40.79)(1.37-.12)}{3.146} = 7844 \text{ cfs}$$

TRY RATIONAL METHOD - 3HR. STORM

assume no retention by soil after 3 HRS.

$$Q_p = CIA = 1.00\left(\frac{1.37}{3 \text{ HRS}}\right) 640\,(40.79)$$

$$= 11{,}922 \text{ cfs}$$

USE 8900 cfs

FORM D S C - 44

Park Death Valley N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 16
Area Emigrant			**of**
Project	**By** D. D.	**Checked**	**Pkg.**
Feature	**Date** 2/17/84	**Date**	**Account**

III RUNOFF

A 100 YR. FLOOD

AREAS 2 & 3 : EMIGRANT CANYON AND HARRISBURG FLATS

Rainfall Retention Assumptions : Mountains : 0.1"
Flats : 0.25"

Total Retained = 25% flats × .25" + 75% Mtns × .1" = .14 INCHES

T_c = 2.44 HRS. A = 49.63 MI.^{2}

TRY DURATION = 1HR.

$T_p = 1/2 + .6(2.44) = 1.964$

$Q_p = \frac{484(49.63)(0.82-.14)}{1.964} = 8317$ cfs

TRY DURATION = 2HR.

$T_p = 2/2 + .6(2.44) = 2.464$

$Q_p = \frac{484(49.63)(1.06-.14)}{2.464} = 8969$ cfs

TRY DURATION = 3HR.

$T_p = 3/2 + .6(2.44) = 2.964$

$Q_p = \frac{484(49.63)(1.35-.14)}{2.964} = 9806$ cfs

TRY RATIONAL METHOD - 3HR. STORM

assume no retention on soil after 3HRS.

$Q_p = CiA = 0.30\left(\frac{1.35}{3HRS.}\right)640(49.63)$

= 4293 cfs

USE 9375 cfs

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 17
Area EMIGRANT			**of**
Project	**By** D.O.	**Checked**	**Pkg.**
Feature	**Date** 2/21/84	**Date**	**Account**

III RUNOFF

A 100 YR. FLOOD

AREAS 1, 2, & 3 - TOWNE PASS, EMIGRANT CANYON & HARRISBURG FLATS

Rainfall Retention Assumptions: Mountains – 0.1"
Flats – 0.25"

Total Retained = 22% Flats x .25" + 78% Mtns x 0.1 = 0.13 IN.

$T_c = 2.60$ HRS. $A = 70.61$ MI.^{2}

TRY DURATION = 1 HR.

$T_p = 1/2 + .6(2.60) = 2.06$

$$Q_p = \frac{484(70.61)(0.78-0.13)}{2.06} = 10,783 \text{ cfs}$$

TRY DURATION = 2 HR.

$T_p = 2/2 + .6(2.60) = 2.56$

$$Q_p = \frac{484(70.61)(1.02-0.13)}{2.56} = 11,881 \text{ cfs}$$

TRY DURATION = 3 HR.

$T_p = 3/2 + .6(2.60) = 3.06$

$$Q_p = \frac{484(70.61)(1.31-0.13)}{3.06} = 13,179 \text{ cfs}$$

RATIONAL METHOD NOT APPLICABLE FOR SUCH A LARGE AREA.

USE 13,200 cfs

FORM D S C - 44

Park Death Valley N.M. **Area** EMIGRANT	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 18 **of**
Project	**By** D.O. / **Checked**	**Pkg.**
Feature	**Date** 2/84 / **Date**	**Account**

III RUNOFF

B PMP FLOOD

$T_p = D/2 + .6\,T_c$

$Q_p = \dfrac{484\,(A)\,Q_T}{T_p}$

D = DURATION OF STORM (HRS.)
T_c = TIME OF CONCENTRATION (HRS.)
A = AREA (MI)^2
Q_T = TOTAL RAINFALL FOR SPECIFIED DURATI
Q_p = PEAK FLOW AT EMIGRANT R.S.

AREA I – TOWNE PASS – Retention assumptions:

Mountains – 0.1"
Flats – 0.25"

Total retained = 85% of area × .1
+ 15% of area × .25 = .12"

T_c = 1.44 HRS. A = 20.98 MI.^{2}

TRY DURATION 30 MIN.

$T_p = .5/2 + .6(1.44) = 1.114$

$Q_p = \dfrac{484\,(20.98)(3.07 - .12)}{1.114} = 26{,}890$ cfs

TRY DURATION = 1 HR.

$T_p = 1/2 + .6(1.44) = 1.364$

$Q_p = \dfrac{484\,(20.98)(4.32 - .12)}{1.364} = 31{,}267$ cfs

TRY RATIONAL METHOD:

Not applicable in this situation because a storm must be of length longer than the T_c, which according to "Design of Small Dams" will not occur.

USE 31,275 cfs

FORM D S C - 44

Park DEATH VALLEY N.M. Area EMIGRANT	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 19 of
Project	By D. D.	Checked	Pkg.
Feature	Date 2/17/94	Date	Account

III RUNOFF

B PMP FLOOD

AREA 2 - EMIGRANT CANYON

Rain Retention Assumptions : Mountains : 0.1"
Flats : 0.25"

Total Retained : 10% flats x .25 + 90% Mount. x .1 = .115 IN.

$T_c = 1.63$ HRS $A = 19.81$ MI.^{2}

TRY DURATION = 30 MIN.

$$T_p = .5/2 + .6(1.63) = 1.228$$

$$Q_p = \frac{484(19.81)(3.11 - .115)}{1.228} = 23{,}385 \text{ cfs}$$

TRY DURATION = 45 MIN.

$$T_p = .75/2 + .6(1.63) = 1.353$$

$$Q_p = \frac{484(19.81)(3.35 - .115)}{1.353} = 26{,}468 \text{ cfs}$$

TRY DURATION = 1 HR

$$T_p = 1/2 + .6(1.63) = 1.478$$

$$Q_p = \frac{484(19.81)(4.38 - .115)}{1.478} = 27{,}668 \text{ cfs}$$

RATIONAL METHOD NOT APPLICABLE HERE

USE 27,670 cfs

FORM D S C - 44

Park DEATH VALLEY N.M. **Area** EMIGRANT	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 20 **of**
Project	**By** D.O.	**Checked**	**Pkg.**
Feature	**Date** 3/84	**Date**	**Account**

III RUNOFF

B PMP FLOOD

AREAS 1 & 2 : TOWNE PASS AND EMIGRANT CANYON

Rainfall retention assumptions : Mountains : 0.1"
Flats : 0.25"

Total Retained = Ave. of 1 & 2 = 0.12"

T_c = 1.91 HRS. A = 40.79 MI.^{2}

TRY DURATION = 45 MIN.

$$T_P = .75/2 + 0.6(1.91) = 1.521$$

$$Q_P = \frac{484(40.79)(3.33-0.12)}{1.521} = 41,665 \text{ cfs}$$

TRY DURATION = 1 HR.

$$T_P = 1/2 + 0.6(1.91) = 1.646$$

$$Q_P = \frac{484(40.79)(3.78-0.12)}{1.646} = 43,899 \text{ cfs}$$

RATIONAL METHOD NOT APPLICABLE HERE —

USE 43,900 CFS

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 21
Area EMIGRANT			**of**
Project	**By** D.D.	**Checked**	**Pkg.**
Feature	**Date** 2 - 84	**Date**	**Account**

III RUNOFF

3 PMP FLOOD

AREAS 2 & 3 : EMIGRANT CANYON AND HARRISBURG FLATS

Rainfall retention assumptions: Mountains : 0.1"
Flats : 0.25"

Total Retained = 25% flats x .25" + 75% mtns x .1" = .14"

$T_c = 2.44$ HRS. $A = 49.63$ MI.^{2}

TRY DURATION = 45 MIN.

$T_p = {}^{3/4}/_2 + .6(2.44) = 1.839$

$Q_p = \frac{484(49.63)(3.17-.14)}{1.839} = 39,578$ cfs

TRY DURATION = 1 HR.

$T_p = 1/2 + .6(2.44) = 1.964$

$Q_p = \frac{484(49.63)(3.60-.14)}{1.964} = 42,318$ cfs

RATIONAL METHOD NOT APPLICABLE HERE ——

USE 42,325 CFS

FORM D S C - 44

Park DEATH VALLEY N.M.		**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 22
Area EMIGRANT				**of**
Project	**By** D. O.		**Checked**	**Pkg.**
Feature	**Date** 2/21/34		**Date**	**Account**

III RUNOFF

B PMP FLOOD

AREAS 1,2 & 3 - TOWNE PASS, EMIGRANT CANYON & HARRISBURG FLATS

Rainfall Retention Assumptions : Mountains - 0.1"
Flats - 0.25"

Total Rainfall Retained = 22% Flats x 0.25" + 78% Mtns x 0.1" = 0.13"

T_c = 2.60 HRS. A = 70.61 MI.^{2}

TRY DURATION = 45 MIN.

$$T_p = .75/2 + 0.6(2.60) = 1.935$$

$$Q_p = \frac{484(70.61)(2.80-.14)}{1.935} = 46,980 \text{ cfs}$$

TRY DURATION = 1HR.

$$T_p = 1/2 + 0.6(2.60) = 2.06$$

$$Q_p = \frac{484(70.61)(3.18-.14)}{2.06} = 50,433 \text{ cfs}$$

LONGER DURATIONS AND THE RATIONAL METHOD
ARE NOT APPLICABLE.

USE 50,500 cfs

MESQUITE

CAMPGROUND

BASELINE FLOODPLAIN ANALYSIS

Death Valley National Monument

California and Nevada

Flood Mitigation Studies
Package 271

REPORT ON AREAS:

COW CREEK:

FC-1	Park Village
FC-2A	NPS Maintenance
FC-2B	School Wash
FC-2C	Cow Creek Drainage

FURNACE CREEK:

FC-3	NPS Headquarters and Ranch
FC-5	Furnace Creek Inn, Water Supply, & Indian Village
FC-6	Furnace Creek to Zabriskie Point

STOVEPIPE WELLS

SP-1	Mosaic Canyon
SP-2	Stovepipe Wells Development

EMIGRANT
Emigrant Canyon
Emigrant Ranger Station

→ MESQUITE CAMPGROUND

SCOTTY'S CASTLE

SC-1	Tie Canyon
SC-2	Castle Area
SC-2	Water Supply
SC-3	Grapevine Canyon

Prepared by:
Dan Overzet, Civil Engineer, DSC
R.F. Brunson, Civil Engineer, DSC
Ron Greslin, Student Engineer, DSC

MESQUITE CAMPGROUND

GENERAL BACKGROUND

An introduction to the general flood problems of Death Valley, geographic setting, general discussion of precipitation, and the equations used to determine flood flows for different probabilities of frequency are included in a study titled Potential Hazards from Flood Flows and Debris Movement in the Furnace Creek Area, by John R. Crippen, USGS, 1979.

An additional study entitled "Potential Hazards from Flood Flows in Grapevine Canyon, Death Valley National Monument, California and Nevada" by James C. Bowers, USGS, was completed in 1983. This latter study examines the geographic setting of Grapevine and Tie Canyons, the precipitation of the area, flood hydrology, cross-sections with flood extents in Grapevine Canyon, and the potential hazards for Grapevine Canyon and Scotty's Castle area. Grapevine Canyon drainage area is a portion of the drainage area for the Mesquite Campground.

PURPOSE

The purpose of this study is to determine (1) the precipitation and runoff for the drainage area above Mesquite Campground by methods based on gauged rainfall of record and basin characteristics; (2) the extent of flooding at a selected critical section; and (3) some possible methods of flood mitigation.

STUDY AREA

The area of concern for this report includes a large, 505 square mile drainage area as shown on the USGS topography map on page 3. The area forms the drainage basin and collects the runoff which passes through the Mesquite Springs Campground in Death Valley Wash.

Table 1 on page 4 gives the drainage area characteristics for the Mesquite Campground drainage basin for the entire basin and for a 100 square mile portion of the basin which is the maximum area that can be used in computing the runoff for a probable maximum precipitation (PMP) storm.

METHODOLOGY

Precipitation for the 100-year storm was determined using the procedures and isopluvials in NOAA ATLAS 2, Volume XI, prepared by the National Oceanic and Atmospheric Administration. Precipitation for the probable maximum storm and the maximum general-type storm was determined using the procedures and isohyets as prescribed in DESIGN OF SMALL DAMS, Second Edition, Bureau of Reclamation.

Runoff was determined by the procedures described in DESIGN OF SMALL DAMS, and USGS Topographic Maps: Magruder Mountain, Last Chance, Dry Mountain, Tin Mountain, Ubehebe Crater, and Bonnie Claire SW, California; and Gold Point and Gold Point SW, Nevada.

Precipitation and runoff for the areas are summarized in Table 2 on page 5.

Flood extents at critical section were determined using Manning's Formula with an "n" value of 0.045 and a cross-section of the drainage taken on-site. The following plan showing the location of the section was taken from USGS topography map, Tin Mountain, California.

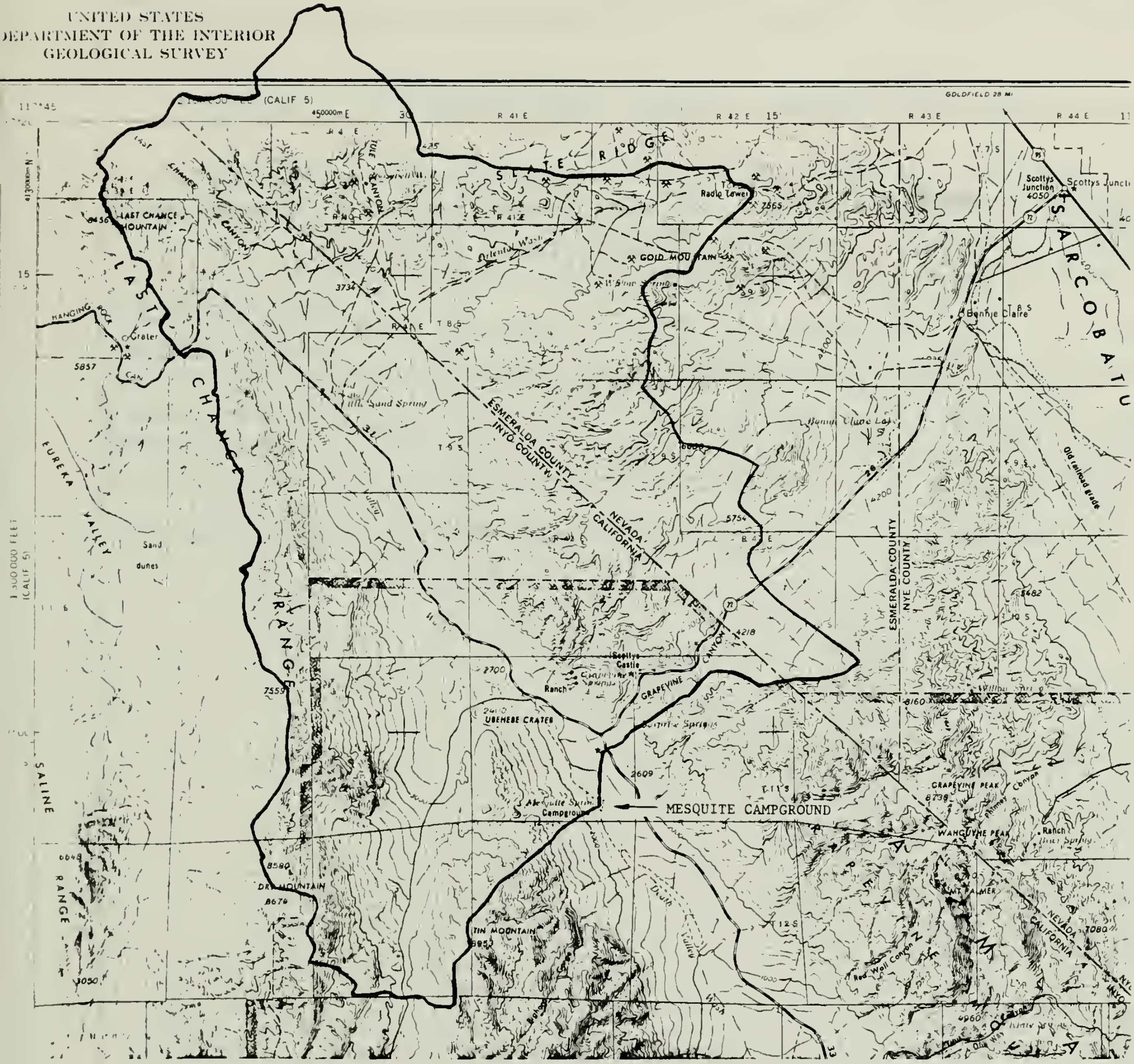
RESULTS

One section was taken in the field in the approximate location shown on a portion of Tin Mountain Quadrangle, USGS Topography Map, on page 6. The section is shown on page 7 with the flow depths for the 2-year, 10-year, 25-year, 50-year, 100-year, probable maximum, and maximum general-type storms.

The two-year storm will be about 6½ feet deep in Death Valley Wash; and the 10-year storm runoff will be about 9½ feet deep and will almost fill the wash. For storms of greater runoff than the 10-year frequency, a vertical wall was assumed which would contain the flow. The 25-year storm requires a wall 1½ feet high; the 50-year storm, 2 feet; the 100-year storm, 3 feet; the probable maximum thunderstorm, 5 feet; and the probable maximum general-type storm, 8 feet.

RECOMMENDATIONS FOR FURTHER STUDY AND FLOOD MITIGATION

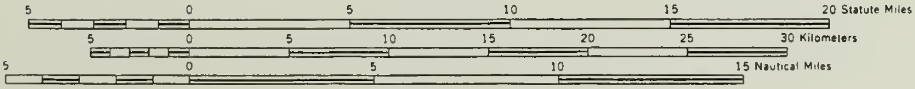
During seasons of highest flood possibility, overnight camping could be barred from near the wash. A warning system should be installed to be implemented during potentially hazardous thunderstorms to prevent hiking or other activities within wash area proper.



MESQUITE SPRINGS CAMPGROUND DRAINAGE AREA

DEATH VALLEY NATIONAL MONUMENT

Scale 1:250,000



CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION
DATUM IS MEAN SEA LEVEL

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** DENVER SERVICE CENTER	Sheet 4
Area MESQUITE SPRGS. CMPG.		of
Project	By / Checked	Pkg.
Feature	Date / Date	Account

TABLE I - DRAINAGE AREA CHARACTERISTICS

AREA NAME	AREA (SQ. MI.)	LENGTH MILES	TIME OF CONCEN. (HOURS)	ELEV. MAX. FEET	ELEV. MIN. FEET	AVE. CHANNEL SLOPE FEET/FT.
MESQUITE SPGS. GENERAL STORM	505.2	40.4	6.8	9046	1760	.025
MESQUITE SPGS. *PMP STORM	100	20.4	3.5	8953	1760	.036

*Probable Maximum Precipitation

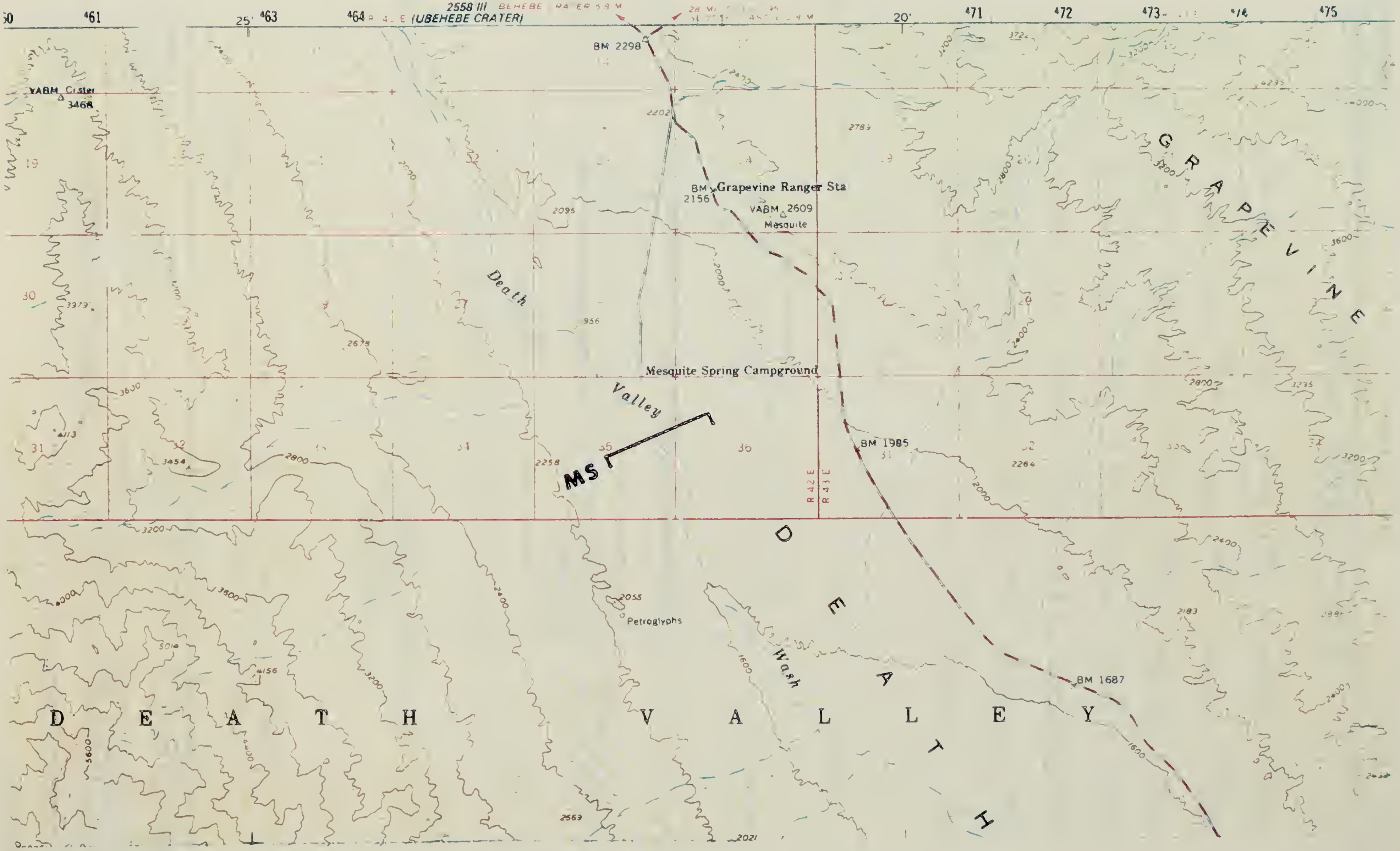
FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	Sheet 5
Area MESQUITE SP. C.G.		of
Project	By R. G. / Checked	Pkg.
Feature	Date 6/26/84 / Date	Account

TABLE II - PRECIPITATION AND RUNOFF

RAINFALL DURATION (HRS.)	2 yr.	10 yr.	25 yr.	50 yr.	100 yr.	PROB. MAX. PRECIP.	GENERAL TYPE MAXIMUM STORM
1/2	.22"	.39"	.40"	.45"	.50"	—	—
1	.32"	.41"	.57"	.65"	.73"	2.85"	—
1 1/2	—	—	—	—	—	3.33"	—
2	.44"	.58"	.79"	.87"	.95"	3.59"	—
2 1/2	—	—	—	—	—	3.75"	—
3	.51"	.73"	.82"	.98"	1.04"	3.82"	—
4	.58"	.82"	.99"	1.10"	1.21"	—	—
5	.63"	.89"	1.06"	1.18"	1.33"	—	—
6	.66"	.97"	1.15"	1.24"	1.39"	—	2.09"
8	.74"	1.09"	1.34"	1.44"	1.58"	—	2.47"
10	—	—	—	—	—	—	2.84"
12	—	—	—	—	—	—	3.20"
14	—	—	—	—	—	—	3.47"
16	—	—	—	—	—	—	3.70"
18	—	—	—	—	—	—	3.91"
20	—	—	—	—	—	—	4.08"
22	—	—	—	—	—	—	4.24"
24	1.02"	1.61"	2.05"	2.17"	2.5"	—	4.39"
RUNOFF (cfs)	13,300	24,000	31,500	32,800	38,300	51,500	70,300

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

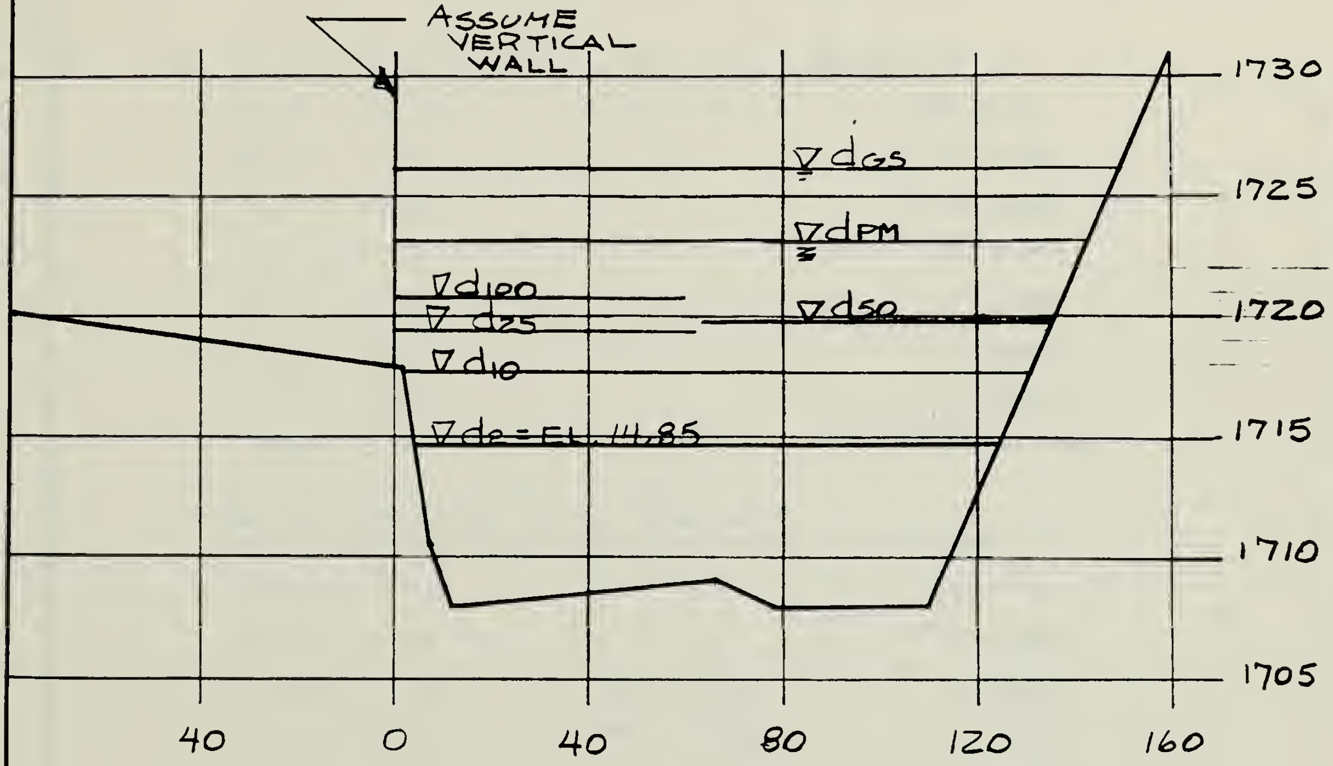


MESQUITE SPRINGS CAMPGROUND

FORM D S C - 44

Park	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 7
Area MESQUITE SPGS. CMPGD.			of
Project	By	Checked	Pkg.
Feature MS - SECTION OF WASH	Date	Date	Account

SECTION WAS TAKEN IN THE FIELD.
BASE ELEV. IS ASSUMED



Q_2 = 13,300 ; V_2 = 17.5 ; d_2 = EL. 1714.85

Q_{10} = 24,000 ; V_{10} = 21.0 ; d_{10} = EL. 1717.75

Q_{25} = 31,500 ; V_{25} = 23.5 ; d_{25} = EL. 1719.45

Q_{50} = 32,800 ; V_{25} = 23.8 ; d_{50} = EL 1719.8

Q_{100} = 38,300 ; V_{100} = 25.0 ; d_{100} = EL 1720.8

Q_{PM} = 51,500 ; V_{PM} = 27.4 ; d_{PM} = EL. 1723.2

Q_{GS} = 70,300 ; V_{GS} = 30.4 ; d_{GS} = EL. 1726.2

SECTION MS

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 8
Area MESQUITE SPRING C.G.			of
Project	By Z. G.	Checked	Pkg.
Feature	Date 6/20/84	Date	Account

II PRECIPITATION

A FIND PRECIPITATION FOR 100 yr. FREQUENCY

X3 = 100 yr. 6 hr [illegible] = [illegible]

X24 = 100 yr. 24 hr [illegible] = [illegible]

Y100 = 100 yr. 1 hr = .322 + .381 [X3 X3/X24] = 1.12 INCHES/HR

FIND AMOUNTS FOR VARIOUS DURATIONS

100 yr., 30 min. (.79)(1.12) = .88 INCHES
100 yr., 1 HR. = 1.12 INCHES
100 yr., 2 HR. = 1.26 INCHES
100 yr., 3 HR. = 1.33 INCHES
100 yr., 4 HR = 1.51 INCHES
100 yr., 5 HR. = 1.62 INCHES
100 yr., 6 HR. = 1.67 INCHES
100 yr., 8 HR. = 1.88 INCHES

REDUCE FOR AREA SIZE (500 mi²)

100 yr., 30 min. (.57)(.88) = .50 INCHES
100 yr., 1 HR. (.65)(1.12) = .73 INCHES
100 yr., 2 HR. (.75)(1.26) = .95 INCHES
100 yr., 3 HR. (.78)(1.33) = 1.04 INCHES
100 yr., 4 HR. (.80)(1.51) = 1.21 INCHES
100 yr., 5 HR (.82)(1.62) = 1.33 INCHES
100 yr., 6 HR. (.83)(1.67) = 1.39 INCHES
100 yr., 24 HR. (.9)(2.75) = 2.50 INCHES

100 yr., 8 HR. (.84)(1.88) = 1.58 INCHES (FROM FIGURES 16 & 4.)

INFORMATION FROM NOAA ATLAS 2 VOLUME XI FOR CALIFORNIA

FORM D S C - 44

Park DEATH VALLEY N. M. Area MESQUITE SP. C. G.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 9 of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

II PRECIPITATION

B FIND PRECIPITATION FOR 2 yr. FREQUENCY

6-HR 2 yr. Point = .80" = X_1

24-HR, 2 yr. Point = 1.12" = X_2

Y_2 = .005 + .852 [$X_1 \cdot X_1 / X_2$] = .005 + .852 [(.80)(.80)/1.12] = .49"/HR.

FIND AMOUNTS FOR VARIOUS DURATIONS

2 yr., 30 min (.79)(.49) = .39 INCHES

2 yr., 1 HR. = .49 INCHES

2 yr., 2 HR. = .58 INCHES

2 yr., 3 HR. = .66 INCHES

2 yr. 4 HR = .72 INCHES

2 yr. 5 HR. = .77 INCHES

2 yr. 8 HR. = .88 INCHES

REDUCE FOR AREA SIZE

2 yr., 30 min. (.57)(.39) = .22 INCHES

2 yr., 1 HR. (.65)(.49) = .32 INCHES

2 yr., 2 HR. (.75)(.58) = .44 INCHES

2 yr., 3 HR. (.78)(.66) = .51 INCHES

2 yr., 4 HR. (.80)(.72) = .58 INCHES

2 yr., 5 HR. (.82)(.77) = .63 INCHES

2 yr., 6 HR. (.83)(.80) = .66 INCHES

2 yr., 24 HR. (.91)(1.12) = 1.02 INCHES

2 yr. 8 (.84)(.88) = .74 INCHES.

INFORMATION FROM NOAA ATLAS 2 VOLUME XI FOR CALIFORNIA.

FORM D S C - 44

Park [illegible]	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 10
Area [illegible]			**of**
Project	**By**	**Checked**	**Pkg.**
Feature	**Date** [illegible]	**Date**	**Account**

II PRECIPITATION

C FIND PRECIPITATION FOR 10 YR. FREQUENCY

6 HR., 10 YR. POINT = [illegible]"

24 HR, 10 YR. POINT = 1.77

FROM FIGURE [illegible] (NOAA ATLAS 2 VOLUME I)

r_{10} = .53 [illegible]

FIND AMOUNTS FOR VARIOUS DURATIONS

10 yr., 30 min. (.53)(.93) = .50

10 yr., 1 HR. = .65 INCHES

10 yr., 2 HR. = .77 INCHES

10 yr. 3 HR = .93 INCHES

10 yr 4 HR = 1.03 INCHES

10 yr. 5 HR = 1.09 INCHES

10 yr. 6 HR = 1.17 INCHES

10 yr. 8 HR = 1.30 INCHES

REDUCE FOR AREA SIZE

10 yr., 30 min. (.57)(.50) = .29 INCHES

10 yr., 1 HR. (.65)(.65) = .41 INCHES

10 yr., 2 HR. (.75)(.77) = .58 INCHES

10 yr., 3 HR. (.78)(.93) = .73 INCHES

10 yr., 4 HR. (.80)(1.03) = .82 INCHES

10 yr., 5 HR. (.82)(1.09) = .89 INCHES

10 yr., 6 HR. (.83)(1.17) = .97 INCHES

10 yr., 24 HR. (.9[illegible])(1.77) = .61 INCHES

10 yr., 8 HR. (.84)(1.30) = [illegible] INCHES

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 11
Area MESQUITE SP. C.G.			**of**
Project	**By** R. S.	**Checked**	**Pkg.**
Feature	**Date** 6/21/84	**Date**	**Account**

II PRECIPITATION

D FIND PRECIPITATION FOR 25 yr. FREQUENCY

6 HR., 25 yr. POINT = 1.38"

24 HR., 25 yr. POINT = 2.25"

Y_{25} = .38 INCHES/HR.

FIND AMOUNTS FOR VARIOUS DURATIONS

25 yr., 30 MIN.	(.79)(1.38")	=	.70	INCHES
25 yr., HR.		=	.88	INCHES
25 yr., 2 HR.		=	1.05	INCHES
25 yr., 3 HR.		=	1.13	INCHES
25 yr., 4 HR.		=	1.24	INCHES
25 yr., 5 HR.		=	1.29	INCHES
25 yr., 6 HR.		=	1.38	INCHES
25 yr., 8 HR.		=	1.60	INCHES

REDUCE FOR AREA SIZE

25 yr., 30 MIN.	(.57)(.70)	=	.40	INCHES
25 yr., 1 HR.	(.65)(.88)	=	.57	INCHES
25 yr., 2 HR.	(.75)(1.05)	=	.79	INCHES
25 yr., 3 HR.	(.73)(1.13)	=	.82	INCHES
25 yr., 4 HR	(.80)(1.24)	=	.99	INCHES
25 yr., 5 HR	(.82)(1.29)	=	1.06	INCHES
25 yr., 6 HR.	(.83)(1.38)	=	1.15	INCHES
25 yr., 24 HR.	(.91)(2.25)	=	2.05	INCHES
25 yr., 8 HR.	(.84)(1.60)	=	1.34	INCHES

INFORMATION FROM NOAA ATLAS 2 VOLUME XI FOR CALIFORNIA.

FORM D S C - 44

Park DEATH VALLEY N.M. **Area**	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 12 **of**
Project MESQUITE SP. C.G.	**By** R.G.	**Checked**	**Pkg.**
Feature	**Date** 6/21/84	**Date**	**Account**

II PRECIPITATION

E FIND PRECIPITATION FOR 50yr. FREQUENCY

6 HR., 50 YR POINT = 1.49"

24 HR, 50yr. POINT = 2.33"

Y_{50} = 1.00"/HOUR.

FIND AMOUNTS FOR VARIOUS DURATIONS

50yr, 30 MIN.	(.79)(1.00)	=	.79	INCHES
50yr., 1 HR.		=	1.00	INCHES
50yr., 2HR.		=	1.16	INCHES
50yr., 3 HR.		=	1.25	INCHES
50yr., 4 HR.		=	1.37	INCHES
50yr., 5 HR.		=	1.44	INCHES
50yr., 6 HR.		=	1.49	INCHES
50yr., 8HR.		=	1.72	INCHES

REDUCE FOR AREA SIZE

50yr., 30 MIN.	(.57)(.79)	=	.45	INCHES
50yr., 1HR.	(.65)(1.00)	=	.65	INCHES
50yr., 2HR	(.75)(1.16)	=	.87	INCHES
50yr., 3 HR	(.78)(1.25)	=	.98	INCHES
50yr., 4 HR.	(.80)(1.37)	=	1.10	INCHES
50yr., 5 HR.	(.82)(1.44)	=	1.18	INCHES
50yr., 6 HR.	(.83)(1.49)	=	1.24	INCHES
50yr., 24 HR.	(.93)(2.33)	=	2.17	INCHES
50yr., 8 HR.	(.84)(1.72)	=	1.44	INCHES

INFORMATION FROM NOAA ATLAS 2 VOLUME II FOR CALIFORNIA.

FORM D S C - 44

Park DEATH VALLEY N. M.	NATIONAL PARK SERVICE DENVER SERVICE CENTER	Sheet 13
Area MESQUITE SP. C. G.		of
Project	By Z. [illegible] · Checked	Pkg.
Feature	Date 3/21/84 · Date	Account

II PRECIPITATION

F GENERAL TYPE MAXIMUM STORM FOR 500 mi²

6 HR POINT = 3 INCHES.

REDUCE FOR AREA: (.695)(3") = 2.09

RAINFALL FOR VARIOUS DURATIONS

6 HR. 2.09"
8 HR (1.18)(2.09) = 2.47"
10 HR (1.36)(2.09) = 2.84"
12 HR (1.53)(2.09) = 3.20"
14 HR. (1.66)(2.09) = 3.47"
16 HR. (1.77)(2.09) = 3.70"
18 HR. (1.87)(2.09) = 3.91"
20 HR. (1.95)(2.09) = 4.08"
22 HR. (2.01)(2.09) = 4.20"
24 HR. (2.10)(2.09) = 4.39"

G PROBABLE MAXIMUM PRECIPITATION (100 sq. mi.)

1 HOUR POINT = 6

REDUCE FOR AREA: 6"(.475 @ 100 sq. mi.) = 2.85"

PMP RAINFALL FOR VARIOUS DURATION

1 HR 2.85
1½ HR. (1.17)2.85 = 3.33
2 HR. (1.26)2.85 = 3.59
2½ HR. (1.315)(2.85) = 3.75
3 HR. (1.34)(2.85) = 3.82

FORM D S C - 44

Park	NATIONAL PARK SERVICE DENVER SERVICE CENTER		Sheet 14
Area MESQUITE C.G.			of
Project	By	Checked	Pkg.
Feature	Date	Date	Account

$\boxed{\text{III}}$ RUNOFF

$\boxed{\text{A}}$ 100 YEAR FLOOD

$$T_p = \frac{D}{2} + .6\,T_c$$

$$Q_p = \frac{484\,(A)\,Q_T}{T_p}$$

T_p = time to peak, hrs.
T_c = time of conc., hrs.
Q_T = Total rainfall for D, inch.
Q_p = Peak flow, cfs

Assume: Mountains are 50% of area @ .1" rainfall retention. Valleys are 50% of area & retain 0.5 inches of rainfall.

Try Duration = 5 hrs.

$$T_p = \frac{5}{2} + .6(6.8) = 6.58 \text{ hrs}$$

$$Q_p = \frac{484\,(505.16)\left[1.33 - (50\% \text{ of } .1 + 50\% \text{ of } .5)\right]}{6.58}$$

$$Q_p = 38{,}300 \text{ cfs}$$

Try Duration = 6 hrs

$$T_p = \frac{6}{2} + 4.08 = 7.08$$

$$Q_p = \frac{484(505.16)(1.39 - .30)}{7.08} = 37{,}600$$

Try Rational Method for 6 hrs.

Say 50% runs off at T_c

$$.5\left(\frac{1.39}{6}\right) 640\,(505.16) = 37{,}450 \text{ cfs}$$

WAANANEN AND CRIPPEN (USGS)

$$Q_{100} = 1080A^{.71} = 89{,}700 \text{ cfs}$$

USE 38,300

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 15
Area			**of**
Project	**By**	**Checked**	**Pkg.**
Feature	**Date**	**Date**	**Account**

$\boxed{II}$ RUNOFF

$\boxed{B}$ 2 YEAR FLOOD

$$T_p = \frac{D}{2} + .6\,T_c$$

$$Q_p = \frac{484\,(A)\,Q_T}{T_p}$$

Assume: Mountains retain .1 on 50% of area.
Valleys retain 0.50 on 50% of area.
Rain fall absorbed = 0.30 inches

Try Duration = 5 hrs.

$$T_p = 5/2 + .6(6.8) = 6.58$$

$$Q_p = \frac{484(505.2)(.63 - .30)}{6.58} = 12{,}300 \text{ cfs}$$

Try Duration = 6 hrs

$$T_p = 6/2 + 4.08 = 7.08$$

$$Q_p = \frac{484(505.2)(.66 - .3)}{7.08} = 12{,}430 \text{ cfs}$$

Try Duration = 8 hrs.

$$T_p = 8/2 + 4.08 = 8.08$$

$$Q_p = \frac{484(505.2)(.74 - .3)}{8.08} = 13{,}300 \text{ cfs}$$

Rational Method for 8 hrs.

Assume 50% runs off

$$Q_p = .5\left(\frac{.74}{8}\right)640(505.16) = 14{,}950 \text{ cfs}$$

USE 13,300 cfs

FORM D S C - 44

Park	**NATIONAL PARK SERVICE** DENVER SERVICE CENTER		Sheet 16
Area			of
Project	By RFB	Checked	Pkg.
Feature	Date	Date	Account

III RUNOFF

C 10 YEAR FLOOD

Assume : 0.30" rainfall retained

Try Duration = 5 hrs.

$T_p = 5/2 + 4.08 = 6.58$

$$Q_p = \frac{484(505.2)(.89-.3)}{6.58} = 21,924$$

Try Duration = 6 hrs.

$T_p = 6/2 + 4.08 = 7.08$

$$Q_p = \frac{484\ (505.2)(.97-.3)}{7.08} = 23,140$$

Try Duration = 8 hrs

$T_p = 8/4 + 4.08 = 8.08$

$$Q_p = \frac{484\ (505.2)(1.09-.3)}{8.08} = 23,900$$

Rational Method for 8 hrs.

Assume 50% runs off

$$Q_p = .5\left(\frac{1.09}{8.08}\right) 640\,(505.2) = 21,808$$

USE = 24,000 cfs

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	Sheet 17
Area MESQUITE SP. C.G.		of
Project	By R. G.	Checked	Pkg.
Feature	Date [illegible]	Date	Account

III RUNOFF

1 25 YR. FLOOD

$T_p = \frac{D}{2} + .6\,T_c$

$Q_p = \frac{484\,A\,Q_r}{T_p}$

0,3" RETAINED BY MOUNTAINS

$T_c = 6.8$ HRS. $A = 505.16\ mi^2$

TRY DURATION = 4 HRS.

$T_p = \frac{4}{2} + .6(6.8) = 6.08$

$Q_p = \frac{484(505.16)(.99 - .3)}{6.08} = 27,800$ cfs.

TRY DURATION = 5 HRS.

$T_p = \frac{5}{2} + .6(6.8) = 6.58$

$Q_p = \frac{484(505.16)(1.06 - .3)}{6.58} = 28,200$ cfs

TRY DURATION = 6 HRS.

$T_p = \frac{6}{2} + .6(6.8) = 7.08$ HRS

$Q_p = \frac{484(505.16)(1.15 - .3)}{7.08} = 29,300$ cfs

TRY DURATION = 8 HRS

$T_p = \frac{8}{2} + .6(6.8) = 8.08$

$Q_p = \frac{484\ (505.16)(1.34 - .3)}{8.08} = 31,470$

RATIONAL METHOD at 6 HRS.

Assume 50% runs off

$Q_p = .5\left(\frac{1.15}{6}\right) 505.2(640) = 31,000$

USE 31,500 CFS

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 18
Area MESQUITE SP. C.G.			**of**
Project	**By** [illegible]	**Checked**	**Pkg.**
Feature	**Date** [illegible]-25/84	**Date**	**Account**

I RUNOFF

E 50 YR. FLOOD

$T_P = \frac{D}{2} + (.6)T_C$

$Q_P = \frac{484\,A(Q_T)}{T_P}$

.3" RETAINED BY MOUNTAIN:

$T_C = 6.8$ HRS. $A = 505\ mi^2$

TRY DURATION = 4 HRS.

$T_P = \frac{4}{2} + (.6)(6.8) = 6.08$

$Q_P = \frac{484(505.16)(1.10-.3)}{6.08} = 32{,}200$ cfs

TRY DURATION = 5 HRS.

$T_P = \frac{5}{2} + (.6)(6.8) = 6.58$

$Q_P = \frac{484(505.16)(1.18-.3)}{6.58} = 32{,}700$ cfs

TRY DURATION = 6 HRS.

$T_P = \frac{6}{2} + (.6)(6.8) = 7.08$

$Q_P = \frac{484(505.16)(1.24-.3)}{7.08} = 32{,}500$ cfs

RATIONAL METHOD (6 HRS.)

$Q_P = (.5)(\frac{1.24}{6})(640)(505.16) = 33{,}400$ cfs

USE 32,800 CFS

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 19
Area MESQUITE SP. C.S.			of
Project	By R. [illegible]	Checked	Pkg.
Feature	Date 6/25/84	Date	Account

III | RUNOFF

F | GENERAL TYPE MAXIMUM STORM (500 mi²) FLOOD

$T_p = \frac{D}{2} + .6\,T_c$

$Q_p = \frac{484\,(A)\,Q_T}{T_p}$

.3 INCH RETAINED BY MOUNTAINS & VALLEYS

TRY DURATION = 8 HRS.

$T_p = \frac{8}{2} + .6(6.8) = 8.08$

$Q_p = \frac{484\,(500.16)(2.47-.3)}{8.08} = 65{,}600$ cfs.

TRY DURATION = 10 HRS.

$T_p = \frac{10}{2} + .6(6.8) = 9.08$

$Q_p = \frac{484\,(500.16)(2.84-.3)}{9.08} = 68{,}400$ cfs.

TRY DURATION = 12 HRS.

$T_p = \frac{12}{2} + .6(6.8) = 10.08$

$Q_p = \frac{484\,(500.16)(3.2-.3)}{10.08} = 70{,}300$ cfs.

TRY DURATION = 14 HRS.

$T_p = \frac{14}{2} + .6(6.8) = 11.08$

$Q_p = \frac{484\,(500.16)(3.47-.3)}{11.08} = 70{,}000$ cfs

WAANANEN & CRIPPEN $Q_{100} = [illegible]\,A^{[illegible]}(A^{.5}+5)^{-1.34}$

$= [illegible]\,(500.16)^{[illegible]}(500.16^{.5}+5)^{-1.34} = 403{,}709$ cfs.

RATIONAL METHOD (6 HRS.) $Q = 0.5\left(\frac{2.09}{6}\right)(640)(500.16) = 56{,}300$ cfs

MATTHAI $Q = 10{,}000\,A^{.6} = 10{,}000\,(500.16)^{.6} = 490{,}325$ cfs.

USE 70,300 cfs

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 20
Area MESQUITE SP. C.G.		**of**
Project	**By** R.S. / **Checked**	**Pkg.**
Feature	**Date** 3-25-84 / **Date**	**Account**

III RUNOFF

G PROBABLE MAXIMUM PRECIPITATION (100 mi²)

$T_P = \frac{D}{2} + .6\ T_C$

$Q_P = \frac{484\ A\ Q_T}{T_P}$

.3" RETAINED BY MOUNTAINS AND VALLEYS

$T_C = 3.5$ HRS. $A = 100$ mi²

TRY DURATION = 1 HR.

$T_P = \frac{1}{2} + (.6)(3.5) = 2.6$

$Q_P = \frac{484(100)(2.85 - .3)}{2.6} = 47,500$ cfs.

TRY DURATION = 1/2 HR.

$T_P = \frac{.5}{2} + (.6)(3.5) = 2.35$

$Q_P = \frac{484(100)(2.33 - .3)}{2.35} = 51,500$ cfs

TRY DURATION = 2 HRS.

$T_P = \frac{2}{2} + (.6)(3.5) = 3.1$

$Q_P = \frac{484(100)(3.59 - .3)}{3.1} = 51,400$ cfs

WAANANEN & CRIPPEN $Q_{me} = 98,000\ (100)^{1.029}\ (\sqrt{100} + 5)^{-1.341}$

= 29[illegible], 266 cfs.

MATTHAI $Q = [illegible],000\ (100)^{.6} = 13[illegible],555$ cfs.

RATIONAL METHOD (3 HRS.)

$Q = (0.7)\left(\frac{3.82}{3}\right)(640)(100) = 57,000$ cfs

USE 51,500 cfs.

•U.S. GPO: 1984-778-378

SCOTTY'S CASTLE

BASELINE FLOODPLAIN ANALYSIS

Death Valley National Monument
California and Nevada

Flood Mitigation Studies
Package 271

REPORT ON AREAS:

COW CREEK:
- FC-1 Park Village
- FC-2A NPS Maintenance
- FC-2B School Wash
- FC-2C Cow Creek Drainage

FURNACE CREEK:
- FC-3 NPS Headquarters and Ranch
- FC-5 Furnace Creek Inn, Water Supply, & Indian Village
- FC-6 Furnace Creek to Zabriskie Point

STOVEPIPE WELLS
- SP-1 Mosaic Canyon
- SP-2 Stovepipe Wells Development

EMIGRANT
- Emigrant Canyon
- Emigrant Ranger Station

MESQUITE CAMPGROUND

→ SCOTTY'S CASTLE
- SC-1 Tie Canyon
- SC-2 Castle Area
- SC-2 Water Supply
- SC-3 Grapevine Canyon

Prepared by:
Dan Overzet, Civil Engineer, DSC
R.F. Brunson, Civil Engineer, DSC
Ron Greslin, Student Engineer, DSC

GRAPEVINE CANYON -- SCOTTY'S CASTLE

GENERAL BACKGROUND

An introduction to the general flood problems of Death Valley, geographic setting, general discussion of precipitation, and the equations used to determine flood flows for different probabilities of frequency are included in a study titled Potential Hazards from Flood Flows and Debris Movement in the Furnace Creek Area, by John R. Crippen, USGS, 1979.

An additional study entitled "Potential Hazards from Flood Flows in Grapevine Canyon, Death Valley National Monument, California and Nevada" by James C. Bowers, USGS, was completed in 1983. This latter study examines the geographic setting of Grapevine and Tie Canyons, the precipitation of the area, flood hydrology, cross sections with flood extents in Grapevine Canyon and in the immediate vicinity of Scotty's Castle, and the potential hazards for Grapevine Canyon and Scotty's Castle area.

PURPOSE

The purpose of this study is to determine (1) the precipitation and separate and combined runoff for SC-1, SC-2, and SC-3 by methods based on gauged rainfall of record and basin characteristics; (2) the extent of flooding at selected critical sections; and (3) the locations which require some method of flood mitigation.

STUDY AREAS

The areas of concern for this report include three drainage basins shown on the USGS map on page 5 as SC-1, Tie Canyon; SC-2, Grapevine Canyon area; and SC-3, lower Grapevine Canyon. Table 1 on page 6 gives the drainage area characteristics for SC-1, SC-2, and SC-3. Scotty's Castle is located at the mouth of drainage area SC-2. Flood amounts for SC-2 will also be used for the water intake area for Scotty's Castle which is located about one mile above Scotty's Castle. Topography maps indicate that the Grapevine Ranger Station is located outside of the floodplain about one mile below the mouth of Grapevine Canyon (SC-3).

METHODOLOGY

Precipitation for the 100-year storm was determined using the procedures and isopluvials in NOAA ATLAS 2, Volume XI, prepared by the National Oceanic and Atmospheric Administration. Precipitation for the probable maximum thunderstorm was determined using the procedures and isohyets as prescribed in DESIGN OF SMALL DAMS, Second Edition, Bureau of Reclamation.

Runoff was determined by the procedures described in DESIGN OF SMALL DAMS, and USGS Topographic Map, Ubehebe Crater, California.

Precipitation and runoff for the areas are summarized in Table 2 on page 7.

Flood extents at critical sections were determined using Manning's Formula with an "n" value of 0.045 and cross-sections of the drainages. The following plans showing the locations of sections at Scotty's Castle were taken from half-size prints of Drawing Number 143-41022.

The topography map showing the locations of sections for the water intake area for Scotty's Castle was just completed in 1985.

RESULTS

SC-1 Tie Canyon. Tie Canyon flows into Grapevine Canyon just downstream from Scotty's Castle. The 100-year flow from Tie Canyon as determined by this study is 4,100 cubic feet per second (cfs), which compares to the 3,900 cfs for the USGS study. The 100-year combined flow of SC-1 and SC-2 (Tie and Grapevine Canyons) for this study is 11,000 cfs compared to the 16,000 cfs for the USGS study. The probable maximum flood for SC-1 is 18,200 cfs and for SC-1 and SC-2 combined is 45,500 cfs. The USGS study estimated the maximum experience floods as 28,300 cfs for SC-1 and 122,000 for SC-1 and SC-2 combined. Tie Canyon contributes to the flooding of the lower Grapevine Canyon. Highway 72 through the lower Grapevine Canyon will be inundated in several locations by the 25-year or larger floods as shown in the cross-sections in the USGS study.

SC-2 Grapevine Canyon. The 100-year flow of 8,500 cfs compares to the 12,100 cfs flow as determined in the USGS study. The probable maximum flood flow is 36,400 cfs for this study; whereas, the maximum experience flow from the USGS study was 93,700 cfs. Flooding of Highway 72 will occur in several locations by smaller flows than the 25-year flood, especially in locations where the road covers nearly the entire canyon floor.

SC-2 Scotty's Castle. A 100-year flow of 8,500 cfs and a probable maximum flow of 36,400 cfs were used for the flood extent calculations at Scotty's Castle. Page 8 shows locations of cross-sections and the extent of the 100-year and probable maximum floods in the Scotty's Castle area.

Section 2B indicates that the highest elevation of the 100-year flow will be more than three feet below the floor of the stable, and the probable maximum flow (PMF) will be about 1/2-foot high on the face of the stable.

Section 2C indicates that the highest elevation of the 100-year flow will be about 1½ feet below the cafe and about 50 feet from the cafe. Much of the parking area will be inundated. A PMF flood would cover the parking area below the cafe and be about 2½ feet high on a protective wall around the cafe.

Section 2D gave results identical to Section 2C.

Section 2E indicates that the 100-year flow will cover about one-third of the parking area below the cafe and the highest elevation will come to 6 feet below the highway. The PMP flood will cover all of the parking area below the cafe and will be up to the level of Highway 72.

Without a protective wall around the cafe, the PMP flood will extend to the limits shown on page and will be about 2 feet deep around the cafe. The cafe would be destroyed by the 20-feet-per-second velocity of the flood.

The final results of this study and the results of the Bowers study are approximately the same.

SC-2 Water Intake Area. A 100-year flow of 8,500 cfs and a PMP flow of 36,400 cfs were also used to determine the flood extent for the water intake area about one mile above Scotty's Castle. The locations of sections and the 100-year and PMP flood extents are shown on page 13 which is a reduction of Drawing Number 143-41096.

Section 2A.1: At this point, the 100-year flood would be overflowing the existing protective dike by about 1/2 foot, and would flood the Spring Box Channel by over 2 feet. The PMP flood would overflow the dike by 6 feet.

Section 2A.2: The 100-year flood will overflow the existing dike by 1½ feet which would cover the spring box by 4 feet, destroying the water collection system. The PMP flood will overflow the existing dike by 6½ feet.

Section 2A.3: The 100-year flood will overflow the existing dike at this location by over 2 feet which will be 4 feet deep around the chlorinator house, which would destroy the house. The PMP flood will overflow the dike by over 8 feet.

Since the dikes will be breached by the 100-year flood, the collection system would be severely damaged by flows of from 2½ to 4 feet around and over the existing facilities.

SC-3 Lower Grapevine Canyon. The combined flows of areas SC-1, SC-2, and SC-3 are 11,500 cfs for the 100-year flood and 55,200 cfs for the PMP flood. The roadway will be covered by up to 4 feet of flood water during a 100-year runoff and by up to 12 feet during a PMP runoff at locations where the roadway is on or near the canyon floor.

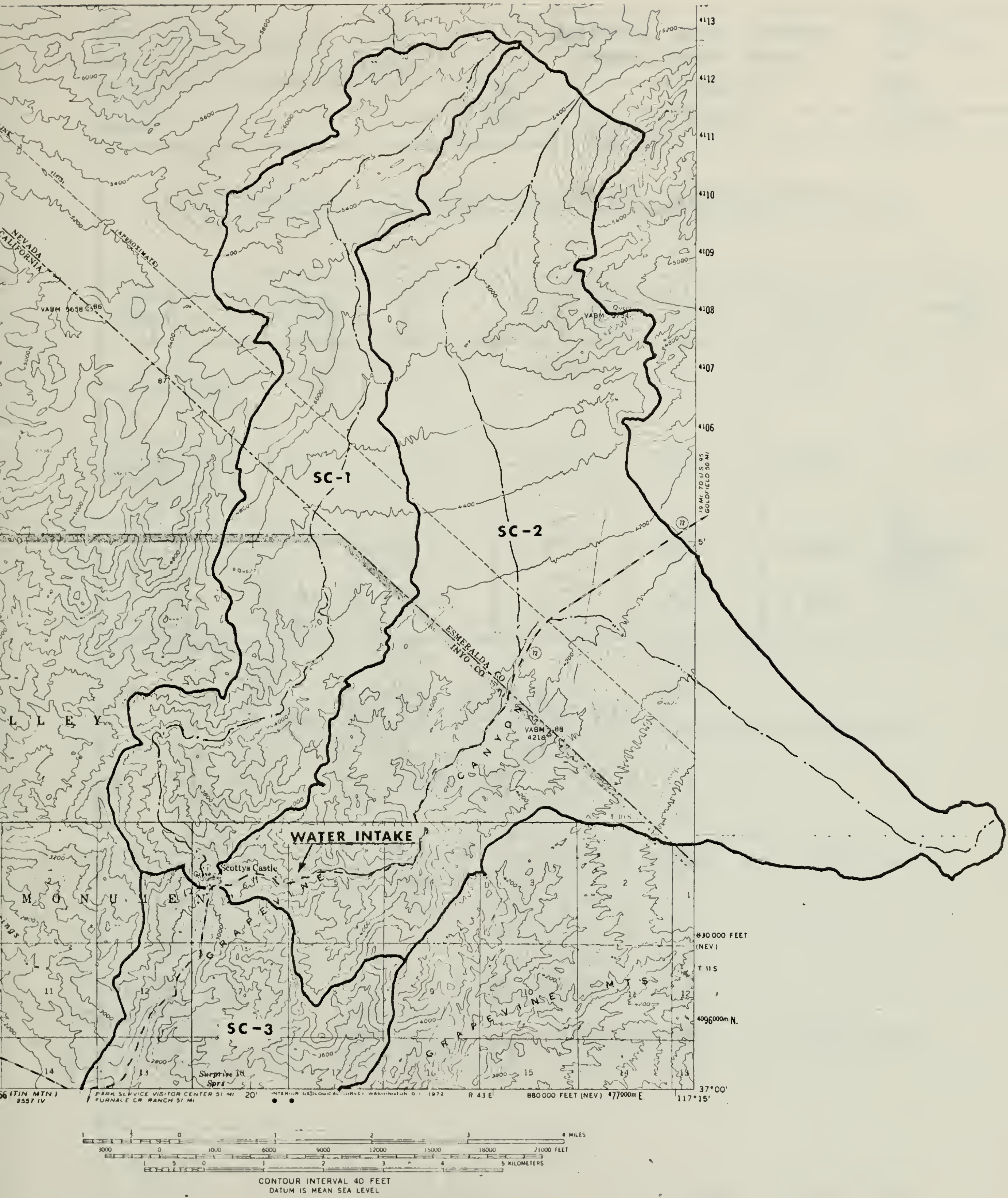
RECOMMENDATIONS FOR FURTHER STUDY AND FLOOD MITIGATION

SC-1 Tie Canyon. Consideration should be given to the eventual redesign and relocation of Highway 72 through Grapevine Canyon. Until then, some warning devices during potentially hazardous storms should be used.

SC-2, SC-3 Grapevine Canyon. Highway 72 should be redesigned, especially in the hazardous portions of the Canyon. Warning devices should be used during potentially hazardous periods of rainfall.

SC-2 Scotty's Castle. A low, 4-foot wall to divert PMP flows around the cafe should be installed. To provide protection for 100-year flows, the parking lot should be shortened by 50 feet and raised 3½ feet; however, parking for 50 vehicles would be lost. The displaced parking could be relocated to the south side of the canyon, adjacent to Highway 72. Warning devices for potentially hazardous rainfall conditions should be installed.

SC-2 Scotty's Castle Water Intake Area. Structural protection should be provided for the expected life of the installation, which would be about 50 to 100 years for the water intake. The 100-year flow would require raising the dike about 2½ to 3 feet. The 50-year flows should be determined for this area as further study.



SCOTTY'S CASTLE

FORM DSC - 44

Park DEATH VALLEY N. M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	Sheet 6
Area SCOTTY'S CASTLE AREAS (SC-1, SC-2, SC-3)		of
Project	By R. G. / Checked	Pkg.
Feature	Date 5/29/84 / Date	Account

TABLE 1 — DRAINAGE AREA CHARACTERISTICS

AREA NAME	AREA $(mi)^2$	LENGTH (mi)	TIME OF CONC. (Min)	ELEV. MAX. (FEET)	ELEV. MIN. (FEET)	AVE. CHANNEL SLOPE
SC-1 TIE CANYON	14.26	12.1	124.4	6130	2960	.0496
SC-2 GRAPEVINE CANYON	29.71	11.55	107.3	7008	2960	.0664
SC-1 + SC-2	43.97	12.1	124.4	6130	2960	.0496
SC-3 + SC-1 + SC-2	46.71	14.8	145.7	6130	2280	.0493

TIMES OF CONCENTRATION

$$T_c = \left(\frac{11.9\ L^3}{\Delta E} \right)^{.385}$$

SC-1 TIE CANYON (ALSO SC-1 + SC-2) : $T_c = \left[\frac{11.9\ (12.1)^3}{6130 - 2960} \right]^{.385} = 2.07$ HRS $= 124.4$ Min

SC-2 GRAPEVINE CANYON : $T_c = \left[\frac{11.9\ (11.55)^3}{7008 - 2960} \right]^{.385} = 1.79$ HRS $= 107.3$ MIN

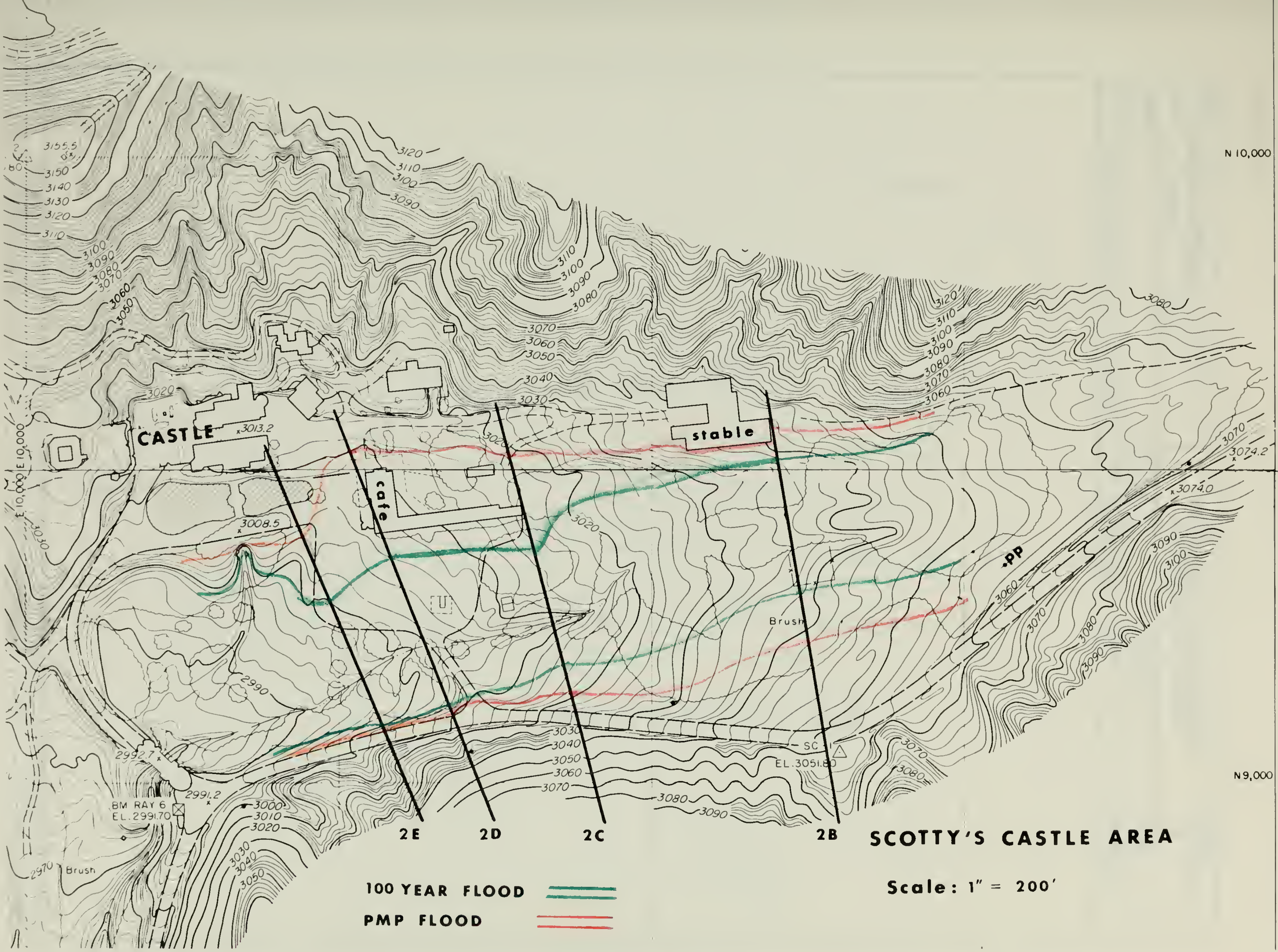
SC-3 + SC-1 + SC-2 : $T_c = \left[\frac{11.9\ (14.8)^3}{6130 - 2280} \right]^{.385} = 2.43$ HRS $= 145.7$ MIN

FORM DSC-44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 7
Area SCOTTY'S CASTLE			**of**
Project	**By** R. G.	**Checked**	**Pkg.**
Feature	**Date** 5/30/84	**Date**	**Account**

TABLE 2 - PRECIPITATION AND RUNOFF

	SC-1	SC-2	SC-1 + SC-2	SC-3+ SC-1 + SC-2
100 YR. PRECIPITATION				
5 MIN.	.35 in.	.35 in.	.35 in.	.35 in.
10 MIN.	.54 in	.54 in.	.54 in	.53 in.
15 MIN.	.68 IN.	.68 in.	.68 in.	.68 in.
30 MIN.	.83 IN.	.73 in.	.68 in	.68 in.
1 HR.	1.12 in.	1.03 in.	1.00 in.	.98 in.
2 HRS.	1.25 in.	1.17 in.	1.14 in.	1.12 in.
3 HRS.	1.46 in.	1.40 in.	1.38 in.	1.37 in.
6 HRS.	1.67 in.	1.62 in	1.60 in.	1.58 in.
PROBABLE MAXIMUM				
15 MIN.	2.19 in.	1.93 in.	1.79 in.	1.76 in.
30 MIN.	3.24 in.	2.85 in.	2.64 in.	2.60 in.
45 MIN.	4.01 in.	3.54 in.	3.27 in.	3.22 in.
1 HR.	4.56 in.	4.02 in.	3.72 in.	3.66 in.
1.5 HRS.	5.34 in.	4.70 in.	4.35 in.	4.28 in.
2 HRS.	5.75 in.	5.07 in.	4.69 in.	4.61 in.
3 HRS.	6.11 in.	5.39 in.	4.99 in.	4.90 in.
AREA (mi^2)	14.26	29.71	43.97	46.71
100 YR RUNOFF (cfs)	4100	8500	11,000	11,500
PROBABLE MAX. RUNOFF (cfs)	18,200	36,400	45,500	55,200

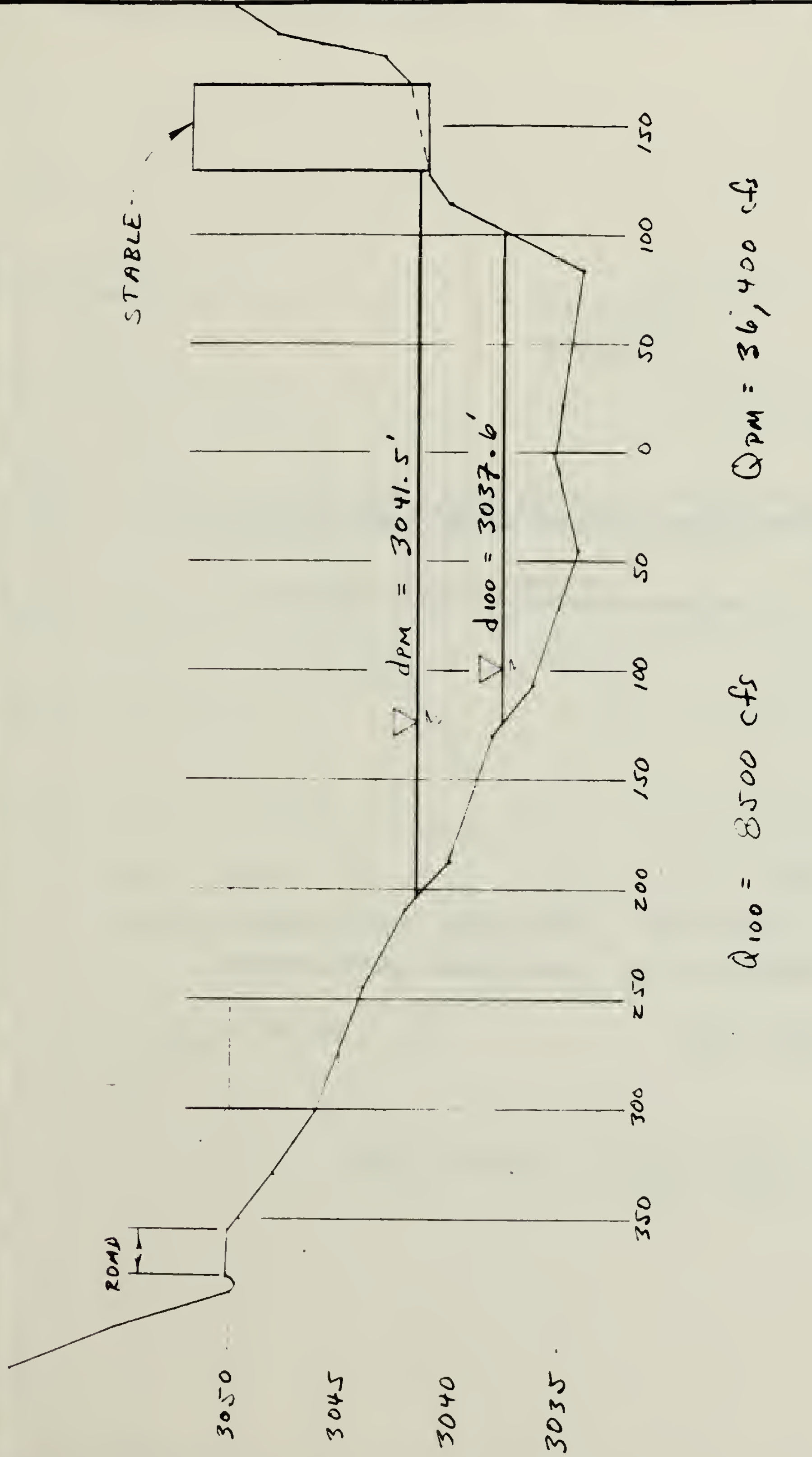


SCOTTY'S CASTLE AREA

Scale: 1" = 200'

FORM D S C - 44

Park DEATH VALLEY N. M. Area SCOTTY'S CASTLE	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 9 of
Project	By R. G.	Checked	Pkg.
Feature CROSS SECTION AT STABLE	Date 6/29/84	Date	Account

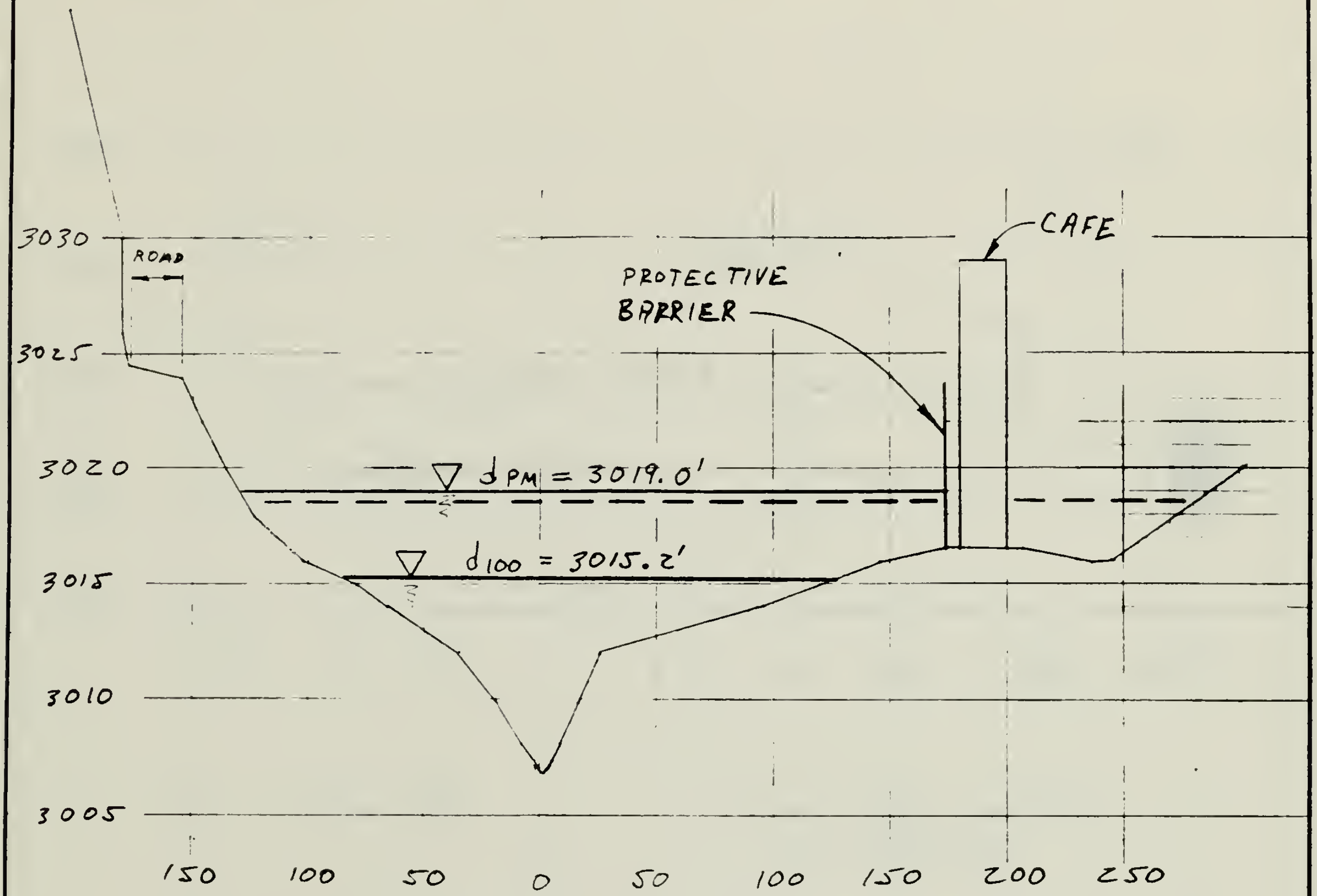


SECTION SC-2B

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 10
Area SCOTTY'S CASTLE			of
Project	By R. G.	Checked	Pkg.
Feature SCOTTY'S CAFE (UPPER)	Date 6/29/84	Date	Account



NOTE: DASHED LINE INDICATES LOCATION OF "d_{PM}" IF NO PROTECTIVE BARRIER IS IN PLACE.

Q_{100} = 8500 cfs

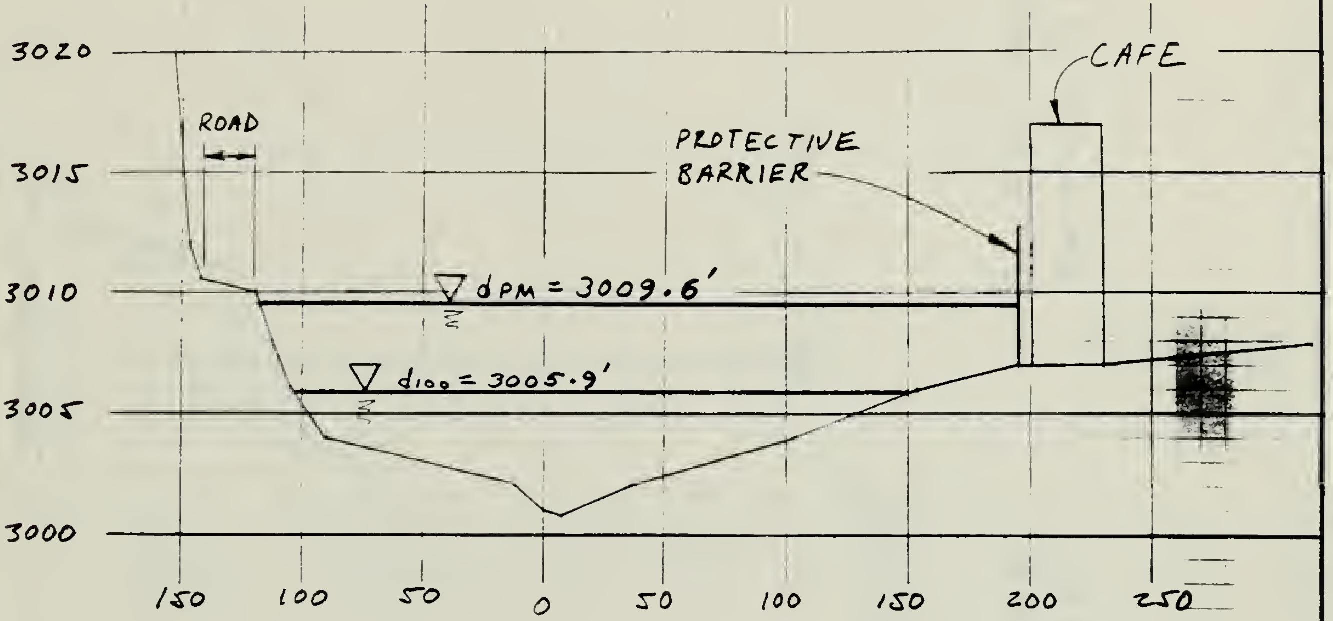
Q_{PM} = 36,400 cfs

SECTION SC-2C

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.M.	NATIONAL PARK SERVICE DENVER SERVICE CENTER	Sheet 11
Area SCOTTY'S CASTLE		of
Project	By R. G.	Checked	Pkg.
Feature SCOTTY'S CAFE (LOWER)	Date 6/29/84	Date	Account



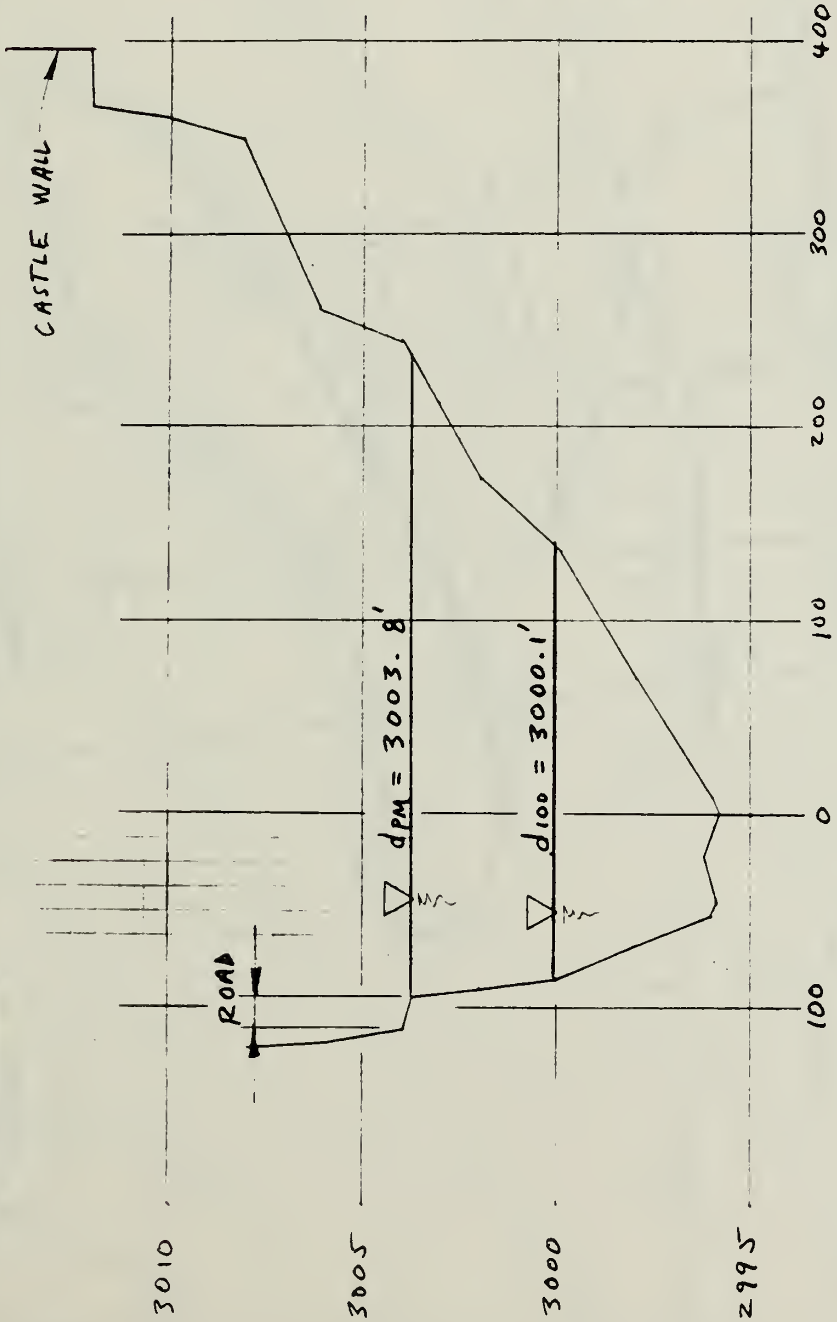
Q_{100} = 8500 cfs

Q_{PM} = 36,400 cfs
V = 20 fps

SECTION SC-2D

FORM D S C - 44

Park DEATH VALLEY N. M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 12
Area SCOTTY'S CASTLE			of
Project	By R. G.	Checked	Pkg.
Feature CROSS SECTION AT CASTLE	Date 5/31/84	Date	Account



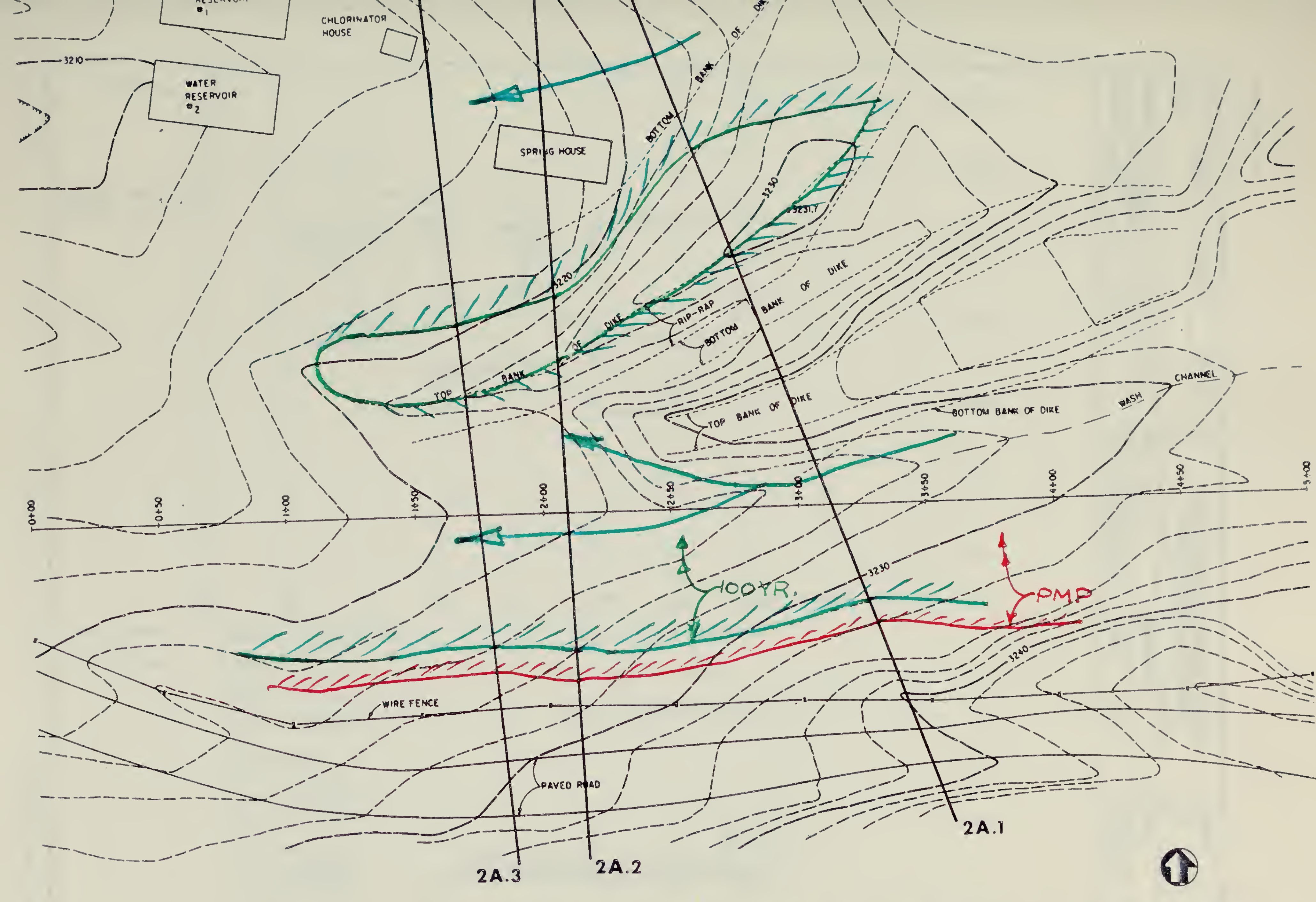
SECTION SC-2E

Q_{PM} = 36,400 cfs
V_{PM} = 17.1 fps

n = .045
s = .053

Q_{100} = 8500 cfs
V_{100} = 12.8 fps

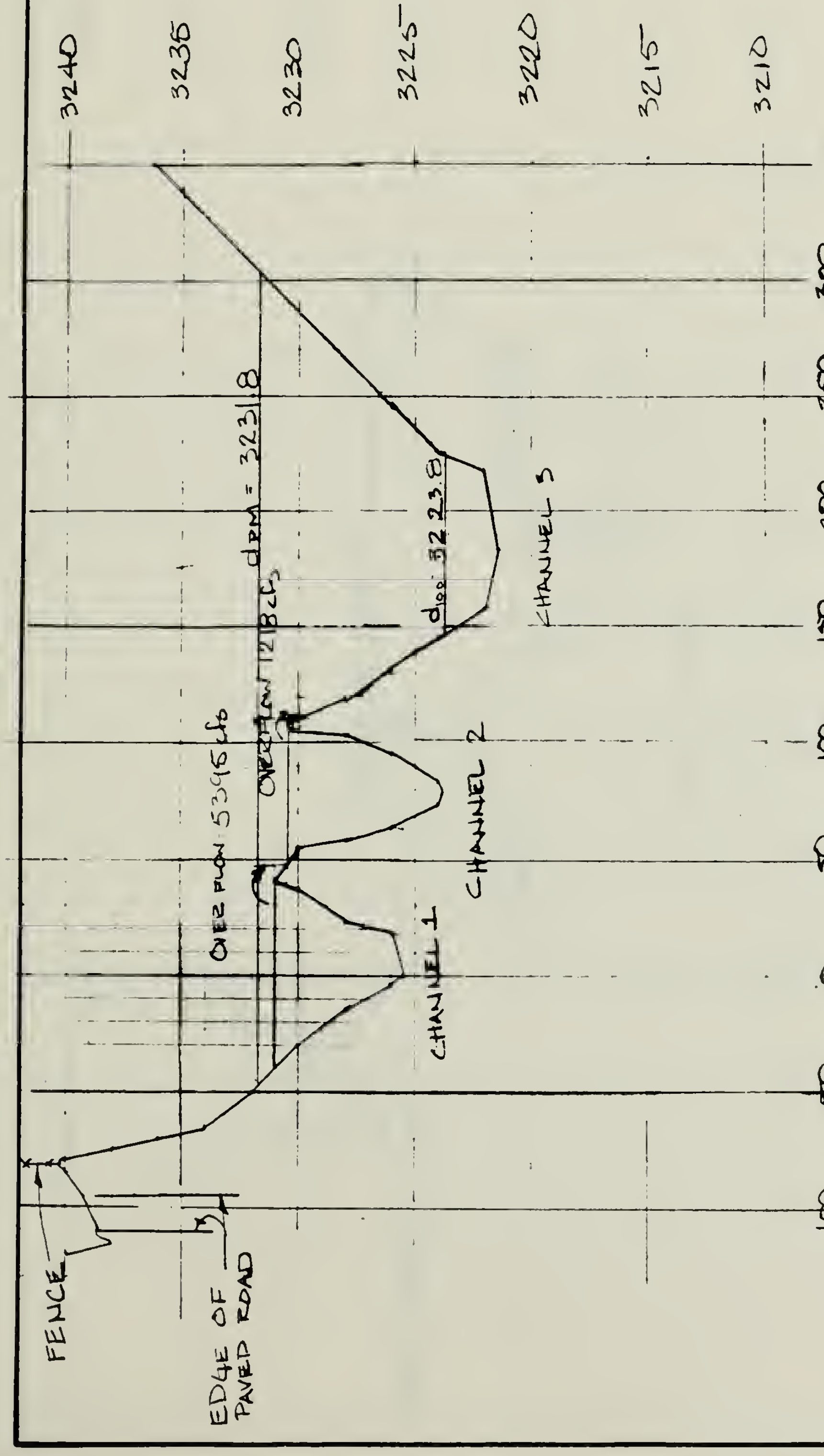
•U.S. GPO: 1984-778-378



SCALE 1"=50 20 0 20 40 60 GRAPHIC SCALE CONTOUR INTERVAL	UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE DENVER SERVICE CENTER	TOPOGRAPHIC SHEET OF SCOTTYS CASTLE WATER INTAKE	REGION	DRAWING NO 143 41 996

FORM D S C - 44

Park DEATH VALLEY N.M **Area**	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 14 **of**
Project WATER INTAKE	**By** T.G	**Checked**	**Pkg.**
Feature SECTION 2A.1	**Date** 4/8/85	**Date**	**Account**



QPM = 36,400 cfs

V = 20.2 fps

Q = 36,400 cfs

SECTION 2A.1

n = 0.045

S = 0.04

Q100 = 8,500 cfs

CHANNEL 1

V = 13.32 fps

Q = 3,165 cfs

CHANNEL 2

V = 16.43 fps

Q = 4177 cfs

CHANNEL 3

V = 9.56 fps

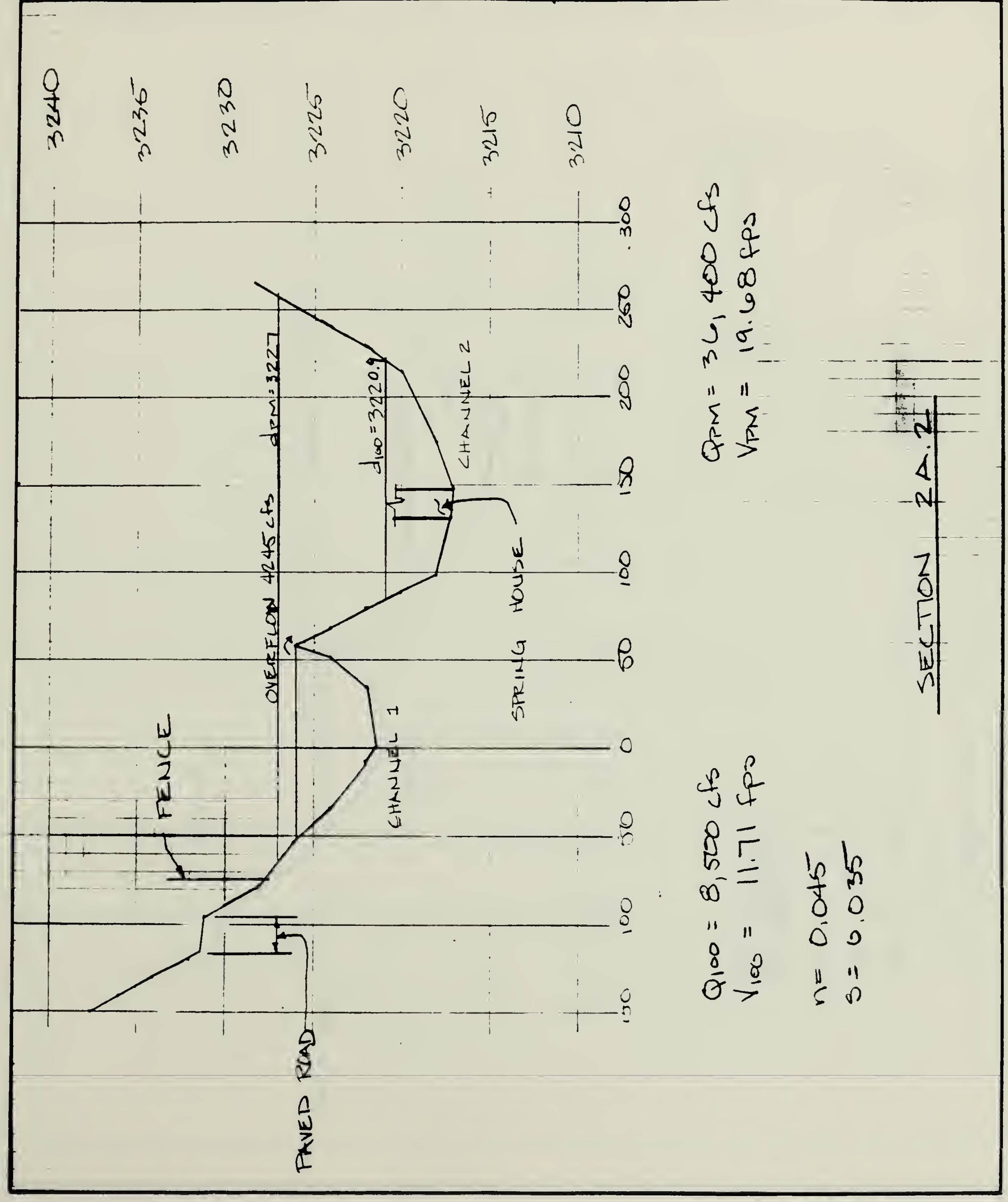
Q = 1218 cfs

d100 = 23.8

FORM D S C - 44

Park DEATH VALLEY	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	Sheet 15
Area		of

Project WATER INTAKE	By T. G.	Checked	Pkg.
Feature SECTION 2A2	Date 4/8/85	Date	Account



Q_{PM} = 36,400 cfs
V_{PM} = 19.68 fps

Q_{100} = 8,500 cfs
V_{100} = 11.71 fps

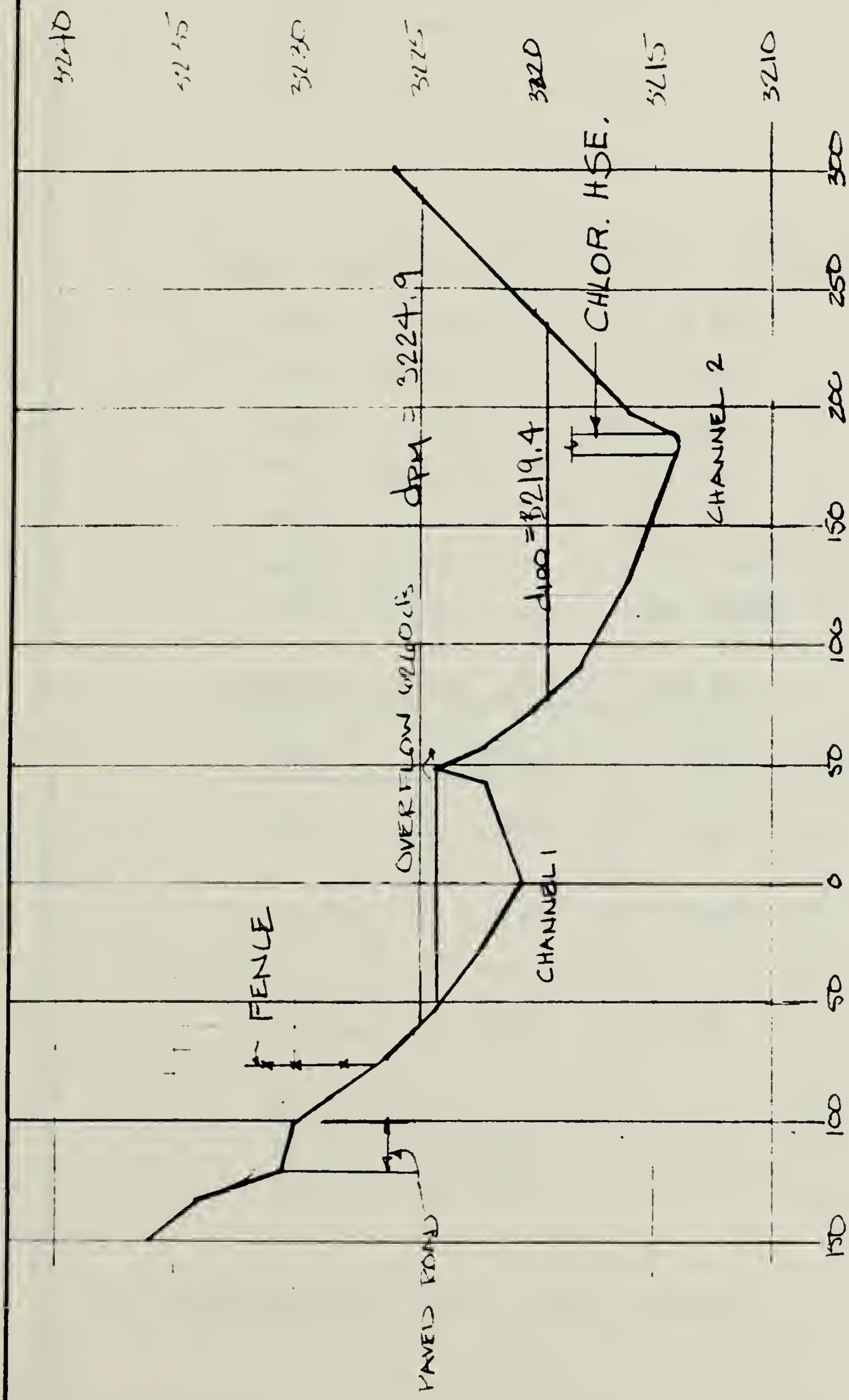
n = 0.045
s = 0.035

SECTION 2A.2

•U.S. GPO: 1984-778-378

FORM D S C - 44

Park DEATH VALLEY N.P.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 16
Area			**of**
Project WATER INTAKE	**By** T.G.	**Checked**	**Pkg.**
Feature SECTION 2A3	**Date** 4/8/85	**Date**	**Account**



Q_{PM} = 36,400 cfs
V_{PM} = 19.10 fps

SECTION 2A3

Q_{100} = 8,500 cfs

CHANNEL 1
V_{100} = 10.32 fps
Q = 2240.5 cfs

CHANNEL 2
Q_{100} = 6259.5 cfs
V_{100} = 12.71 fps

n = 0.045
s = 0.035

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 17
Area SCOTTY'S CASTLE		**of**
Project	**By** Z. G. **Checked**	**Pkg.**
Feature	**Date** 5/30/84 **Date**	**Account**

II PRECIPITATION

A FIND PRECIPITATION FOR 100 YR FREQUENCY - ALL AREAS

6 HR.; 100 yr. POINT = 1.7 INCHES = Y_3 FIG 24

24 HR., 100 yr. POINT = 2.6 INCHES = X_4 FIG. 30

Y_{100} = 100 yr., 1 HOUR RAIN = $0.322 + 0.789\left[(X_3)(X_3/X_4)\right]$

= 1.20 INCHES/HR.

FIND AMOUNTS FOR VARIOUS DURATIONS - TABLE 13

100 yr., 5 MIN = .29 (1.20) = .35 INCHES
100 yr. 10 MIN = .45 (1.20) = .54 INCHES
100 yr. 15 MIN = .57 (1.20) = .68 INCHES
100 yr. 30 MIN = .79 (1.20) = .95 INCHES
100 yr. 1 HR. = 1.0 (1.20) = 1.20 INCHES
100 yr. 2 HR. = 1.30 INCHES } FROM FIG. 15 - Ⓑ
100 yr. 3 HR. = 1.50 INCHES }

REDUCE FOR AREA SIZE

AREA	30 MIN	1 HR.	2 HR.	3 HR.	6 HR.
SC-1	.83	1.12	1.25	1.46	1.67
SC-2	.73	1.03	1.17	1.40	1.62
SC-1 + SC-2	.68	1.00	1.14	1.33	1.60
SC-3 + SC-1 + SC-2	.68	.98	1.12	1.37	1.58

INFORMATION FROM NOAA ATLAS 2 - VOLUME VII FOR NEVADA

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 18
Area SCOTTY'S CASTLE		**of**
Project	**By** / **Checked**	**Pkg.**
Feature	**Date** [illegible] / **Date**	**Account**

II PRECIPITATION (CONT.)

B FIND PROBABLE MAXIMUM RAINFALL

1 HOUR POINT RAINFALL = 6 INCHES/HR

THE DEATH VALLEY AREA IS IN ZONE II -

ADJUST FOR AREA

AREA				
SC-1	(.76)(6)	=	4.56	INCHES/HR.
SC-2	(.67)(6)	=	4.02	INCHES/HR.
SC-1 + SC-2	(.62)(6)	=	3.72	INCHES/HR.
SC-3 + SC-1 + SC-2	(.61)(6)	=	3.66	INCHES/HR

AREA	15 MIN 48% of 1 HR	30 MIN 71% of 1 HR	45 MIN 88% of 1 HR	1 HR 100% of 1 HR	1½ HR 117% of 1 HR	2 HR 126% of 1 HR	3 HR. 134% of 1 HR
SC-1	2.19	3.24	4.01	4.56	5.34	5.75	6.11
SC-2	1.93	2.85	3.54	4.02	4.70	5.07	5.39
SC-1 + SC-2	1.79	2.64	3.27	3.72	4.35	4.69	4.99
SC-3 + SC-1 + SC-2	1.76	2.60	3.22	3.66	4.28	4.61	4.90

INFORMATION FOR PROBABLE MAXIMUM RAINFALL FROM: "DESIGN OF SMALL DAMS" - U.S. DEPT. OF INTERIOR, BUREAU OF RECLAMATION - 1974, PP. 52 - 54.

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 19
Area SCOTTY'S CASTLE (SC-1)			**of**
Project	**By** R J.	**Checked**	**Pkg.**
Feature	**Date** 5/30/84	**Date**	**Account**

III RUNOFF FOR SC-1

A 100 YR. FLOOD

$T_P = D/2 + .6\,T_c$

$Q_P = \dfrac{484\,(A)(Q_T)}{T_P}$

D = DURATION (HRS.)
T_c = TIME of CONCENTRATION (HRS.)
A = AREA $(mi)^2$
Q_T = TOTAL RAINFALL FOR SPECIFIED DURATION
Q_P = PEAK FLOW

ASSUME MOUNTAINS RETAIN .1" OF RAINFALL
$T_c = 2.07$ HRS. $A = 14.26\ mi^2$

DURATION = 30 MIN

$T_P = \dfrac{.5}{2} + (0.6)(2.07) = 1.49$

$Q_P = \dfrac{(484)(14.26\ mi^2)(.83 - .1)}{1.49} = 3381$ cfs.

DURATION = 1 HR

$T_P = \dfrac{1.0}{2} + (.6)(2.07) = 1.74$

$Q_P = \dfrac{(484)(14.26)(1.12 - .1)}{1.74} = 4046$ cfs

DURATION = 2 HRS.

$T_P = \dfrac{2.0}{2} + (.6)(2.07) = 2.24$

$Q_P = \dfrac{(484)(14.26)(1.25 - .1)}{2.24} = 3543$ cfs.

TRY RATIONAL METHOD (2 HRS.) $Q_P = CIA = (1.00)\left(\dfrac{1.25''}{2\ HRS}\right)640(14.26)$
$= 5704$ cfs.

TRY THANANEN AND CRIPPEN $Q_{100} = 1080\,A^{.71} = (1080)(14.26)^{.71} = 7126$ cfs.

USE 4100 cfs

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 20
Area [illegible] 21			**of**
Project	**By**	**Checked**	**Pkg.**
Feature	**Date** [illegible]	**Date**	**Account**

III RUNOFF FOR SC - 2

A 100 YR. FLOOD

$T_c = 1.79$ HRS $\quad A = 29.71\ mi^2$

DURATION = 1 HRS.

$T_p = \frac{1.0}{2} + (.6)(1.79) = 1.57$

$$Q_p = \frac{(484)(29.71)(1.03 - .1)}{1.57} = 8518 \text{ cfs.}$$

DURATION = 2 HRS.

$T_p = \frac{2.0}{2} + (.6)(1.79) = 2.07$

$$Q_p = \frac{(484)(29.71)(1.17 - .1)}{2.07} = 7433 \text{ cfs.}$$

DURATION = 30 min.

$T_p = \frac{.5}{2} + .6(1.79) = 1.32$

$$Q_p = \frac{(484)(29.71)(.73 - .1)}{1.32} = 6863 \text{ cfs.}$$

RATIONAL METHOD (2 HRS)

$$Q_p = (1.00)\left(\frac{1.17}{2}\right) 640(29.71) = 11,123 \text{ cfs}$$

WAANANEN AND CRIPPEN $\quad Q = (1080)(29.71)^{.71} = 12,000$ cfs

USE 8520 cfs

FORM DSC-44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		Sheet 21
Area SCOTTY'S CASTLE (SC-1 + SC-2			of
Project	By Z. S.	Checked	Pkg.
Feature	Date 5/30/84	Date	Account

III RUNOFF FOR SC-1 + SC-2

A 100 YR. FLOOD

$T_c = 2.07$ HRS. $A = 43.97\ mi^2$

DURATION = 30 MIN.

$$T_p = \frac{.5}{2} + (.6)(2.07) = 1.49$$

$$Q_p = \frac{(484)(43.97)(.68-.1)}{1.49} = 8284 \text{ cfs}$$

DURATION = 1 HR.

$$T_p = \frac{1.0}{2} + .6(2.07) = 1.74$$

$$Q_p = \frac{(484)(43.97)(1.00-.1)}{1.74} = 11,007 \text{ cfs}$$

DURATION = 2 HRS.

$$T_p = \frac{2.0}{2} + .6(2.07) = 2.24$$

$$Q_p = \frac{(484)(43.97)(1.14-.1)}{2.24} = 9881 \text{ cfs}$$

RATIONAL METHOD (2 HRS) $Q_p = (1.00)\left(\frac{1.14}{2}\right) 640(43.97) = 16,040$ c

WAANANEN AND CRIPPEN $Q_p = 1050(43.97)^{.71} = 15,851$ cfs.

USE 11,000 cfs.

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 22
Area SCOTTY'S CASTLE (SC-3 - SC-1+SC-2)		**of**
Project	**By** R.G. / **Checked**	**Pkg.**
Feature	**Date** 5/31/84 / **Date**	**Account**

III RUNOFF FOR SC-3 + SC-1 + SC-2

A 100 YR. FLOOD

$T_c = 2.43$ HRS. $A = 46.71\ mi^2$

DURATION = 30 min.

$$T_p = \frac{.5}{2} + .6(2.43) = 1.71$$

$$Q_p = \frac{(484)(46.71)(.68 - .1)}{1.71} = 7668\ cfs$$

DURATION = 1 HR.

$$T_p = \frac{1.0}{2} + .6(2.43) = 1.96$$

$$Q_p = \frac{(484)(46.71)(.98 - .1)}{1.96} = 10,150\ cfs$$

DURATION = 2 HRS.

$$T_p = \frac{2.0}{2} + .6(2.43) = 2.46$$

$$Q_p = \frac{(484)(46.71)(1.12 - .1)}{2.46} = 7374\ cfs$$

RATIONAL METHOD (2 HRS.)

$$Q_p = (1.00)\left(\frac{1.12}{2}\right)(640)(46.71)$$
$$= 16,741\ cfs$$

LURANANEN AND CRIPPEN

$$Q_{100} = (1080)(46.71)^{.71} = 16,546\ cfs$$

USE 11,500 cfs

FORM DSC-44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 23
Area SCOTTY'S [illegible]			**of**
Project	**By**	**Checked**	**Pkg.**
Feature	**Date** [illegible]/34	**Date**	**Account**

III | RUNOFF FOR [illegible]

B | [illegible] FLOOD

$T_p = \frac{D}{2} + .6T_c$

$Q_p = \frac{484(A)(Q_T)}{T_p}$

D = DURATION OF STORM
T_c = TIME OF CONCENTRATION
A = AREA
Q_T = TOTAL RUNOFF [illegible] DURATION
T_p = PEAK [illegible]

ASSUME MOUNTAINS [illegible]
T_c = 2.07 HRS. A = 14.26 mi²

[illegible]

$T_p = \frac{1}{2} + .6(2.07) = 1.74$

$Q_p = \frac{484(14.26)([illegible] - .1)}{1.74} = 17,691$ cfs

DURATION = 1.5 HRS.

$T_p = \frac{1.5}{2} + .6(2.07) =$ [illegible]

$Q_p = \frac{484(14.26)(5.34 - .1)}{1.99} = 18,174$ cfs.

USE 18200

DURATION = 2 HRS.

$T_p = \frac{2}{2} + .6(2.07) =$ [illegible]

$Q_p = \frac{484(14.26)(5.75 - .1)}{3.24} =$ [illegible] cfs.

WAANANEN & CRIPPEN $Q = [illegible] A^{[illegible]} \times (A^{.5} + 5)^{-1.341}$

$= ([illegible])(4.26^{.920}) \times (14.26^{.5} + 5)^{-1.341}$

= [illegible] cfs.

MATTHAI $Q = 11,000A^{.61} = (11,000)(14.26)^{.61}$ = [illegible] cfs.

RATIONAL METHOD (2 HRS.) $Q_p = (1.00)(\frac{5.75}{2})640(14.26) = 26,238$ cfs.

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**		**Sheet** 24
Area SCOTTY'S CASTLE (SC-2)			**of**
Project	**By** [illegible]	**Checked**	**Pkg.**
Feature	**Date** 3/31/80	**Date**	**Account**

III RUNOFF FOR SC-2

B PMP FLOOD

$T_c = 1.79$ HRS $A = 27.71$ mi^2

DURATION = 1 HR.

$T_D = \frac{1.0}{2} + .6(1.79) = 1.57$

$$Q_D = \frac{(434)(27.71)(4.02 - .1)}{1.57} = 35,703 \text{ cfs.}$$

DURATION = 1.5 HR

$T_D = \frac{1.5}{2} + .6(1.79) = 1.82$

$$Q_D = \frac{(454)(27.71)(4.70 - .1)}{1.82} = 36,344 \text{ cfs.}$$

DURATION = 2 HR.

$T_D = \frac{2.0}{2} + .6(1.79) = 2.07$

$$Q_D = \frac{434(27.71)(5.07 - .1)}{2.07} = 34,525 \text{ cfs.}$$

WAANANEN AND CRIPPEN $Q_{MD} =$ [illegible] $(27.71^{.5} + 5)^{-1.301}$

= 1[illegible], 581 cfs.

MATTHAI $Q = (11,000)(27.71)^{.6} =$ 8[illegible] cfs.

RATIONAL METHOD (2 HRS.) $Q_D = (1.00)(\frac{5.07}{2})640(27.71)$

= 48, 20[illegible] cfs.

USE 36,400 cfs

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 25
Area SCOTTY'S CASTLE [illegible]		**of**
Project	**By** [illegible] · **Checked**	**Pkg.**
Feature	**Date** [illegible] · **Date**	**Account**

II | [illegible]

B | [illegible] FLOOD

$T_c = 2.07$ HRS. $A = 43.07\ mi^2$

DURATION - 1 HR.

$T_p = \frac{1.0}{2} + .6(2.07) = 1.74$

$Q_p = \frac{484(43.07)(3.72 - .1)}{1.74} = 44,275$ cfs.

DURATION = 1.5 HRS.

$T_p = \frac{1.5}{2} + .6(2.07) = 1.99$

$Q_p = \frac{484(43.07)(4.35 - .1)}{1.99} = 45,450$ cfs.

DURATION = 2.0 HRS.

$T_p = \frac{2.0}{2} + .6(2.07) = 2.24$

$Q_p = \frac{484(43.07)(4.69 - .1)}{2.24} = 43,608$ cfs.

HANNHNEN AND CRIPPEN

$Q_{me} = 78700(43.07)^{1.033}(43.07^{.5} - 5)^{-1.341}$

$= 180,223$ cfs.

MATTHAI $Q = 1,500(43.07)^{.6} =$ [illegible]

RATIONAL METHOD 24 HR.

$Q_p = (1.00)(\frac{4.69}{2})640(43.07) = 65,$[illegible] cfs

USE 45,000

FORM DSC - 44

Park DEATH VALLEY N.M.	**NATIONAL PARK SERVICE** **DENVER SERVICE CENTER**	**Sheet** 26
Area SCOTTY'S CASTLE (SC-3 + SC-1 + SC-2)		**of**
Project	**By** [illegible] **Checked**	**Pkg.**
Feature	**Date** [illegible] **Date**	**Account**

III | RUNOFF FOR SC-3 + SC-1 + SC-2

B | PMF FLOOD

$T_L = 2.43$ HRS. $A = 46.71 mi^2$

DURATION = 1 HR.

$T_P = \frac{1}{2} + .6(2.43) = 1.46$

$Q_P = \frac{484)(46.71)(3.66 - .1)}{1.46} = 55,125$ cfs.

DURATION = 1.5 HRS.

$T_P = \frac{1.5}{2} + .6(2.43) = 1.99$

$Q_P = \frac{484(46.71)(4.28 - .1)}{1.99} = 47,487$ cfs.

TRY DURATION = 45 min

$T_P = \frac{.75}{2} + .6(2.43) = 1.83$

$Q_P = \frac{484(46.71)(3.22 - .1)}{1.83} = 38,544$ cfs.

THOMAS AND CRIPPEN

$Q_{me} = 98900(46.71)^{1.029}(46.71^{.5} + 5)^{-1.341} = 137,900$ cfs.

MATTHAI

$Q = 11,000(46.71)^{.6} = 114,745$ cfs.

RATIONAL METHOD (2 HRS.)

$Q_P = (1.00)(\frac{4.61}{2})640(46.71) = 68,907$ cfs.

RATIONAL METHOD (3 HRS.)

$Q_P = 1.00(\frac{4.90}{2})640(46.71) = 73,241$ cfs.

USE 55,200 cfs.